Chapters on Plant Life

Herrick

CHAPTERS ON PLANT LIFE

BY

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CHAPTERS ON PLANT LIFE.

CHAPTER I.

INTRODUCTORY.

YOU have read enough Indian stories, I am sure, to know how very different life among savages is from ours. An Indian brave, if he has no family, is obliged to do all his own work. He makes his tent, or wigwam, hunts for his food, gathers sticks for his fire, cooks the animals he has captured—can live his simple life independent of the work of any other man. If he has a family, he only hunts, or fights for their protection, while the women weave the mats, make the moccasins, cook, and even raise some poor, meagre crops. This is what is called a division of labor: not a very equal one in the case of the Indian.

It is found that when one man does one kind of work constantly, and another man another kind, that they each gain so much skill that there is a saving of time and labor. If each exchanges with the other so much of the results of his labor as they need, they are better off. As people get more peaceful and wiser and more civilized, this division goes on more and more.

Something like this civilizing may be seen in the vegetable world as we go from the simpler forms of life to those that are higher. Every plant is made up of one or more bodies called cells. The plant of a single cell is like a single Indian, and does its own work in growing and eating and breathing. Finally it produces more cells like itself. Small, simple plants, such as we shall see among the fairy fungi and odd fish, are either single savages, or savages in families or tribes, banded together for protection and for ease in living, but each one capable of doing everything for itself if it has to.

The higher plants, such as every field and garden and wood afford, are like a great society, such as we live in and make parts of. Each cell of the thousands and thousands has its own work to do for the whole society, and depends not alone upon its own work, but in part upon the work of a great many others.

If we were to try to study one of these plants with its different kinds of cells, at first we would be all puzzled and confused. Cells which were originally alike have so changed in appearance and work that we would learn very little. And so the world *did* learn very little as long as it tried to study in such a way. But of late years people have learned to begin with the A B C's of science, as well as of reading and writing. When we begin to take things up in this way, and arrange them in a sort of order, we find that it is not an order of our inventing, but the order in which God let them grow, way, way back thousands and thousands of years ago, when the

world was being gradually made. If God created them slowly, one after another, the easiest and simplest first, and then those that were less simple afterwards, that is certainly a good reason for studying them in this same order.

I want to begin at the simplest single cell-plant, and try to make it clear to you how these little creatures live and grow and multiply. There are two great divisions in the plant world—the fungous plants and the green plants; and what is true of the tiniest members of these two divisions in regard to their breathing and eating, is true of the greatest. The small fungous plants, like yeast and mould and mildew, and the largest toadstools, live on other living or dead creatures; the green plants draw their food from the earth and air and water. As the fungi are the simplest of all, we will begin with them.

Chapter II.

A FLOWERLESS FLOUR GARDEN.

We all know, in a general way, that nothing grows unless it is alive, and yet who ever thinks of bread dough as having life in it? There never was a garden bed so full of living plants as is the loaf when it is moulded into shape, and ready to be put into the oven. If you have never watched the mixing of bread, I would advise you to go and look at it the first chance you have, for it is a very curious and entertaining bit of gardening. The cook first prepares her seed, which is the yeast. There are several ways of planting common flower-seed, and so there are of planting yeast. You may either soak the seed to make them sprout quickly, or you may start the little plants in a hot-bed; or, again, you may

buy your young seedlings, and transplant them into your own garden plot. Just so you may get your yeast seed ready to plant. The yeast cake may be only melted in warm water, or it may be set to start in a cup of water and flour by the warm kitchen fire, or you may buy the yeast already grown at the baker's.

When the seed or seedlings are ready, the garden plot is prepared. The cook heaps up in her bread bowl quarts of snowy flour. Into this heap, after making a hole, she pours her prepared yeast. Working the bread is only another name for the careful scattering of the seed through all the dough, that it may spring up and grow, and fill the whole mass with the tiny plants.

The yeast plant is not a common kind of plant, but belongs to the same class as mushrooms and toadstools (Fig. 1), and the fuzzy, cottony growth that we call mould. There are two kinds of plants that we may find almost anywhere in the

FIG. 1.—TOADSTOOLS.

fields and woods, and even in the city yards—the fungi and the green plants. The yeast plant is one of the fungi. These are very different in most respects from the green plants: they can live and grow and thrive in darkness; they do

not have either leaves or flowers, and they usually spring up and die very quickly. The greatest real difference between the two kinds is, however, that the fungi live on food that has been alive before—on plants or animals or decaying matter—while the green plants live on what they get out of the earth, and the air, and the water.

The simplest of all the fungi is the yeast plant. It begins its life as a tiny egg-shaped bag, or sac (Fig. 2, *a*). This cell, as it is called, is filled with a very curious jelly, perhaps the most wonderful thing in all the world. It is found in everything that lives and grows. By its help the little yeast plant can take the flour and water, and can change it so that while the paste is used up and disappears, the cells grow larger and sprout out buds. You have particles of this jelly, or *protoplasm*, lining your mouth and stom-

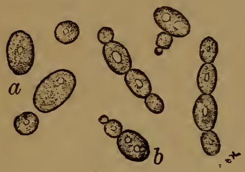

FIG. 2.—YEAST PLANT. (*Torulæ.*)
a, Single cells; *b*, growing plants.

ach, and the food you eat is changed into flesh and blood and bones by this wonder-working magician. In the figures, the grainy substance is the protoplasm.

This jelly all seems to be pretty much alike, no matter in what plant or animal you find it; but there is some marvellous difference somewhere—a difference that science has never reached. The yeast cell takes in certain food, and grows, but it never makes anything but other or larger yeast cells. The food you eat and digest makes just *you*; more of you, perhaps, but still you, yourself, and nobody else.

Like all living things, the tiny yeast cell must both eat and breathe, or it will die. It feeds, not by opening its mouth and taking in its food, but by lying bathed in it, and soaking it up through its skin. When the cook dissolves her yeast cake, and puts it into the mixture of flour and water we call dough, she is putting the little plant into its food bath. The cells which have

been so long in prison, shut up in the darkness and cold of the dried yeast, begin to look alive, and stretch themselves, and enjoy their liberty. They take kindly to their food right away, and begin helping themselves to what they find about them. They do not merely soak up the flour and water in which they are plunged, but they manage to extract from the compound just what they need to make them grow.

The cells must not only *feed* in order to live, but they must *breathe*, they must somehow get oxygen, which is the gas that our breathing takes out of the air. And this they extract, as a miner does iron, by separating it from its ore. There is a certain amount of sugar in wheat, which gives to good bread and to cracked wheat their delicate sweetness of flavor. Sugar is made up of a number of different substances, which the yeast cell has the power of separating. It takes the oxygen for its own use, and leaves behind the other things that make up the sugar. The

change that goes on in the flour and water dough under the influence of the growing yeast plant is called *fermenting*.

Feeding and breathing in this way, by taking what it needs from the flour, the cell grows. When it has reached its mature size, it rests quietly for a while, as if it were gathering strength for the effort, and then it sends out a little bud, which grows like the parent cell, until another bud sprouts from the end of the new sac. When this is grown, it is very unlike our notion of a plant; it is really nothing more than a little chain of sacs growing end to end. As soon as the little plant has exhausted all the sugar and food substance of the flour, it stops growing, the cells separate and remain quite still.

There is just one time in the growth of the plant when the dough is right for baking. Before it has grown enough, the bubbles through the dough are too few or too small, and the bread, if baked at this stage, would be heavy.

These bubbles are the carbonic acid gas left behind when the oxygen has been taken out of the sugar, and there must be plenty of them to make the bread light. If the bread is left too long to rise, the cells get more than their share of the wheat-sugar, and the bread is sour. Just at the right stage, which every good bread-maker can tell by experience, a thorough baking will de-destroy the alcohol—which is one of the things left behind while the yeast is growing—and the bread will be both sweet and light.

When the yeast plant is sowed on the top of the flour and water, instead of being buried in it, all this is very different. The plant takes its food from the paste, but it does not need the sugar to supply it with oxygen, so it lets that alone. It can get its oxygen in a much simpler way, right from the air, as we do, and does not need to go through the labor of smelting it out of the sugar. The raising of our bread by yeast is entirely due to the efforts of the tiny cells to

get a breath of air when we have smothered them up in the dough.

There are other plants besides the yeast plant that act in the same way. Have you never heard your mother say, when she opened a jar

FIG. 3.—MOULD.
(*Penicillium.*)

of preserves, "These are all right, I know, for they are covered with mould?" Mould is a good deal like yeast in some things; if the germ cell, or spore, falls upon the top of the sweet-

meats, it can get plenty of oxygen from the air, and so lets the sugar alone. But if it is nearly drowned in the sirup, it will get its oxygen somehow, and so the sugar has to be sacrificed, and the preserves are left to spoil. What else could you expect of such little mischief-makers if you shut them up with the sweetmeats?

The yeast plant is so very, very small that you cannot see it except with a very fine magnifying glass. But there are other plants like it which are large enough to be seen with a small and not a costly microscope.* These are what we call moulds. If you want to study moulds, nothing

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* There is a little microscope which can be gotten from James W. Queen, 924 Chestnut Street, Philadelphia, called the Child's Microscope, No. 3055, price $3 00, with three lenses. It is in a small walnut box, has a little mirror, stand, two dissecting needles, box for live insects, etc., a pair of forceps, watch glass, and plain slides. It magnifies about thirty-three diameters (nearly 1000 times in area), and gives a good clear image, besides having the advantage of being an excellent pocket glass, even if you should buy a more costly instrument hereafter.

is easier than to prepare them. Mix a spoonful of flour with cold water, and spread the paste over the bottom of a plate or saucer. In a few days it will be covered all over. If you put it in a damp and dark place, the mould will sprout sooner. You might put away a piece of bread at the same time, and you will find it covered with a growth too.

Take a bit of this paste on the blade of a knife, and examine it carefully. You will see among the cottony fibres a number of little upright stems with black or white or yellow heads, which give the mould a speckled look. Under the microscope you see a perfect jungle of growth —a tangle of threads, which look like spun glass, running here and there and everywhere. From these, which serve as roots to the mould, the stems spring up, bearing, instead of leaves or flowers, tiny glistening toadstools that look as if they were made out of a pearl; or sometimes the heads are like strings of little pearls

(Fig. 3), or at others they are rosettes of such strings (Fig. 4, *a*). The black and sage-green colors come later, and are the fruit or seed-bearing portion of the plant (Fig. 4, *b*).

FIG. 4.—MOULD.
(*Aspergillus.*)
a, Rosette Heads; *b*, Fruit.

On my saucer of paste I found in one place a plantation of delicate yellow fungi. The stems came up thick, with the little round fruit at the end of each, looking as if the whole thing was carved out of amber. In another place, over the yawning caverns made by the cracks in the paste,

there were delicate forms like grasses in seed, all looking like spun glass. The largest kind of common mould, which you may see in Fig. 5, is not so beautiful as these I have just described, but it shows very well the way the fungi grow

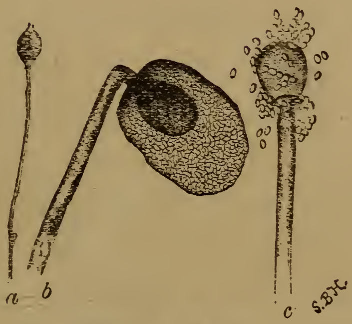


FIG. 5.—MOULD.
(*Mucor.*)
a, Stalk; *b*, same opened; *c*, outer skin broken, and spores scattering.

and form their seed, and then sow themselves. This plant is easily seen with the naked eye, but looked at through the Child's Microscope, you see a great deal more. The stalks look as they do in Fig. 5, *a*. If you are so fortunate as

to have a large microscope, and watch them from day to day, you will see them look as they do in Fig. 5, *b*, and finally, when the outer skin breaks, like *c*, in the same illustration.

A single spoonful of flour will give you this wonderful garden, with its crop of yeast plant, if you sow the seed; or, if you trust to luck, its harvest of chance-sown mould. The air is full of these spores of the mould plants, and wherever they find a place they will take possession of it, and grow up without planting or cultivating, as weeds do. You can be certain of your yeast crop, because you have sowed it; but you must take your chances with the mould. You are almost sure, however, to find in any saucer of paste the different kinds described and pictured in Figs. 3, 4, and 5.

The toadstool, whose picture (Fig. 1) is the first of all the fungi given here, is much larger than the mould, but almost as simple. It is made up of millions upon millions of little cells

in strings or in flat plates, most of them like each other. This is very different from the cells in the higher kinds of plants; they have different kinds of cells for different purposes, as we shall see after a while.

It is worth while sometimes to get away from the every-day world, and learn the wonders that are to be found within the fairy ring to which the microscope admits us.

Chapter III.

THE FAIRY FUNGI.

The hill-sides of the southern part of France are covered with vineyards, where the luscious grapes round out under the late summer sunshine into globes of delicious sweetness. When the grapes are ripe, the peasants—men, women, and children—may be seen gayly trooping to the vineyards to pick them for wine. In the famous Steinburger vineyard the pickers are all girls about eighteen years old. Each girl has a row to pick, and they begin together, and move forward as steadily and evenly as a regiment of soldiers. With their gay petticoats looped up so that they may not brush off the ripe grapes, and their bright stockings and mittens, they make a very pretty picture moving along between the

rows, snipping the ripe grapes, and letting them drop into their baskets. When the baskets are full they are emptied into a tub, which the men lift by leathern straps and carry to the roadside press. The juice which comes spurting out of the press is placed in vats or barrels, and there left to ferment, which changes the juice, or *must*, into wine. When the cook wants her bread to ferment, or rise, she plants it with yeast; but the wine has nothing planted in it, and yet it ferments.

Pasteur, the great French chemist, made up his mind to find why this was. He was convinced from all his studies in fermentation that the reason would be found in some little plant which was growing in the juice and helping itself to whatever it needed to eat or to breathe. He set to work to find out where the plants came from which turned the grape juice into wine. All his experiments are so fully and clearly explained that any one who is willing to take the pains can try them for himself.

He found that there was no fungus growing inside the little closed bag (which we call skin) in which the pulp, seed, and juice of the grape are sealed up. There is no opening anywhere in a sound grape through which spores (which are the fungus seed) could enter. But he found on the skin of the grape, and thickly over the stem, little plants, something like yeast and something like mould; these make up in part what is called the bloom of the grape. He put some water, with these plants mixed through it, into a tightly sealed bottle, and into another he put the pure juice of the grapes which had none of the little plants through it, and then waited to see what would happen. In a few days the water was all yeasty, and the grape juice was unchanged (Fig. 6). He tried this same thing over and over and over again, and in various ways, to be sure that he was right. He thus found that the little magician that turns the juice into wine is always waiting at the door of the sealed

FIG. 6.—GRAPE FUNGUS.

chamber, ready to work its miracle as soon as it can reach the juice.

The case is very different with beer. Pasteur gave a great deal of time and attention to finding out why so many millions of gallons of beer were every year spoiled in the making. The brewers could not tell why. They prepared their wort in just the same way, and planted just the same amount of yeast into the good beer as they did in what turned out to be bad. He brought that wonderful microscope of his to bear upon the subject. He found that whenever the wort was planted with yeast which had certain curious little glassy rods mixed through it, the beer turned sour. The brewer, when he put such yeast as this into his wort, was planting, along with the seeds of the yeast plant, seeds of a troublesome weed. The sour beer was really only a very queer kind of a liquid garden, growing more weeds than useful plants.

Vinegar is another thing made by these little

fairy fungi. The cider out of which it is made is set away in a cask to ferment. The spores that work the change in this case are floating

FIG. 7.—POTATO FUNGUS.
(*Botrytis infestans.*)

in the air, and manage somehow to get into the open cask. Did you ever notice the flakes of muddy-looking substance at the bottom of a vinegar cruet? That is the *mother*, the little plant that has made the cider into vinegar.

These are some of the useful things that are done by the fungi, and they are certainly very valuable services. We owe to them our bread and wine and beer and vinegar. But they are not always benevolent fairies by any means.

FIG. 8.—LEAF MILDEW.
(*Æcidium.*)

Sometimes we are inclined to think that they are at the bottom of pretty much all the mischief in the world. If they were not sailing about in every breath of wind, getting into all sorts of places where they are not wanted, we probably

would never have any chills and fever or diphtheria, and the yellow fever would not sweep off its thousands and tens of thousands. If these little floating spores did not get into every crack and cranny, wounds would not fester, damp linen would not mildew, preserves and pickles would not mould, milk would not sour, nothing would spoil or ferment or decay. There is an old proverb that "the mother of mischief is no bigger than a midge's wing." I sometimes wonder if the old-time people that made the proverbs did not know something of these tiny mischiefs that only seem to be waiting the chance to work their naughty will.

There is one case where this change takes place which you have probably often seen. When I was a child I used to be very fond of getting from the woods close to the house, or from the wood-pile, bits of shining wood and bark, which we called "fox fire." The wood was always old and decaying, and we thought it was

shining because it was dying. But really the perishing wood was covered all over with tiny mushrooms, which shone with a light something like the glimmer of a fire-fly. In some countries this brightness is very wonderful. In Australia people have been able to read by the light of a shining stump overgrown with luminous fungi.

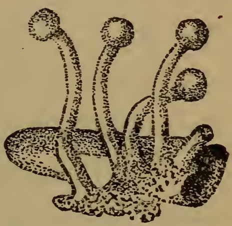


FIG. 9.—RYE SMUT.
(*Cordyceps.*)

Some of the fungi have not even the manners to wait until their victims are dead. They take possession of living plants and animals, and never rest until they have destroyed them. The disease among potatoes called the potato-blight (Fig. 7), of which we hear so much, is caused by the growth of a little fungous plant in the mouths, or breathing holes, on the skin of the potato, and the blight and mildew (Fig. 8) and smut of wheat and corn and rye (Fig. 9) are all due to the same cause. The mouldy look upon

vine leaves is nothing else. I put a leaf of Virginia creeper, which looked whitish and ugly, under the microscope one day, and found the whole surface covered with a net-work of silvery threads, with a wonderful fruit growing upon it. The fruits looked like peeled oranges surrounded with threads of spun sugar, or occasionally like a gigantic blackberry sparkling with crystals. This was only a common mildew, but under the magnifier it seemed a wonderful garden, growing conserves and fairy fruits, and was beautiful beyond description (Fig. 10).

The silk-worm is attacked by a fungous plant (Fig. 11). It takes possession of the worm just before it begins to spin its cocoon, and some years ago it destroyed such multitudes that the French silk trade was seriously threatened. The microscope was again brought into use, and the cause of the trouble discovered, and the cure effected.

The untiring Pasteur studied up this and other diseases of the silk-worm as he did those of wine

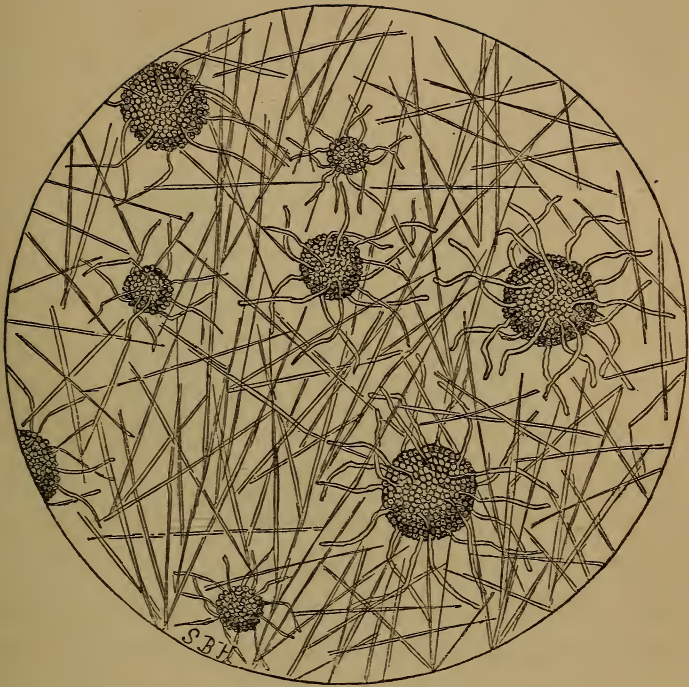


Fig. 10.—Mildew on Virginia Creeper.

(*Erysiphe.*)

and beer, and helped the silk-worm growers to stamp out the disease when it appeared. It perhaps seems a small thing for a man of genius like

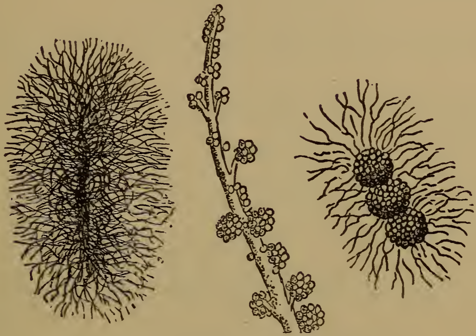


Fig. 11.—Silk-worm Fungus.
(*Botrytis bassiano.*)

Pasteur to give his whole life to studying these little plants through the microscope, but never was a life more helpfully and patriotically spent. Hundreds of thousands of the French peasants depended for daily food and shelter upon what they earned in the wine and beer and silk trades, and these trades Pasteur's work has saved from

destruction or great loss. It has been said that his work with the microscope has saved to France more money than the awful French Revolution cost her.

Chapter IV.

ODD FISH IN THE VEGETABLE WORLD.

I must begin by telling you that these "odd fish" are very little fish indeed, so small that you could not make out anything about them unless you used a magnifying-glass. But if you do, you will be rewarded by seeing some very wonderful things.

Let us go out into the yard; it does not make much difference whether it is a great country garden, with beds of vegetables edged with flowers and threaded by pleasant walks, or a little, narrow, paved, cooped-up city yard, we will be pretty sure to find what we want. Every water-butt and horse-trough, every little puddle left by the rain (if it has stood long enough) is sure to be swarming with one kind or another of these

curious little creatures. If you have no such collections of water, look, and perhaps you will find in the shady corner of your yard a wet, slimy green moss coating the bricks. This you will find, if you examine it through your magnifying-glass, to be made up of thousands and thousands of little green cells. Each of these is one of our odd fish coiled up and asleep. I call them fish, though they are true plants, because they live in the water, or very damp places where there is enough water for them—though it would not be good swimming ground for larger plants or animals—and they go swimming about seeking for food, every now and then settling down to the bottom as if they were tired and wanted to go to sleep.

One of the commonest of these—it has a long Latin name, which means "first-berry"—is also one of the most interesting. The first time I ever saw it I remember my astonishment. I took about a teaspoonful of water out of a little stag-

nant pool that the rain had left in the garden, and poured it into the crystal of a watch. I put it under my microscope and looked in. The little round watery world under my eye was all alive with busy creatures, dashing here and there

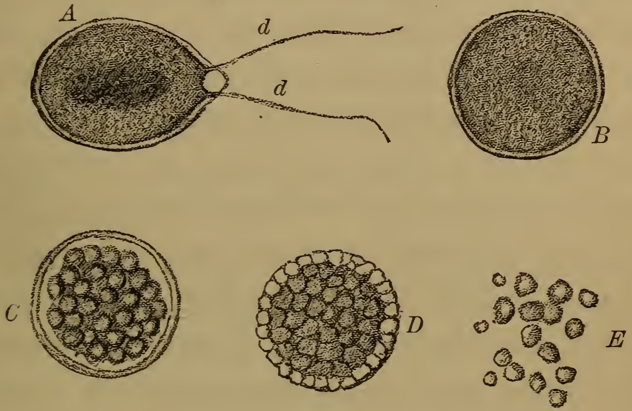


FIG. 12.—FIRST-BERRY FISH.
A, moving; *d d, cilia; B*, still; *C*, multiplying; *D*, red snow-plant; *E*, baby berries swimming freely.

and everywhere. Among other things I found my queer little first-berry fish. He was long and pear-shaped, and moved small end foremost. I

could not see how he managed it, but I knew where to look to find his swimmers (Fig. 12, *A*). Coming out from the two little peaks at the small end there were, I knew, two fine threads called *cilia* (*d d*)—meaning eyelash, because of their shape. With these he whipped through the water, moving himself along just as you do with your arms when you are swimming. For a while I could not see the lashes, they were moving so fast, but after a long time one of the funny little fellows seemed to get tired, he "slowed up," and then the eyelashes could be seen. You see in the picture (Fig. 12, *A*) the berry-fish moving; *d d* are his swimmers. At *B* he is coiled up at rest. If you were to keep them and look at them every little while for several days as I did, you would see a change taking place inside the still cell, *B*. The whole inner part divides in two, then each of these halves divide again, and so on till the inside jelly is divided up into smaller parts; each one of these parts rounds up till the

whole inside of the berry looks like a cluster of small berries (Fig. 12, *C*) enclosed in the outer shell. Finally, the old shell softens and melts away, and then instead of one mother berry you have a whole flock of baby berries that scatter themselves, and soon go lashing about merrily through the water like fish again. At *D*, in the same figure, you may see another member of the family of berry-fish, only he lives in the snow in Greenland and other far north countries. Instead of being green, this snow-plant is red, and the millions of them scattered through the snow give to it a bright red color. I think you must have read something of the wonderful *red snow* in the Arctic regions, and now you know why it is so.

In the same little spoonful of water you may be so fortunate as to find another moving thing that looks like an eel as it goes wriggling about among the other fish. These are really stiff spirals, like a furniture spring, only longer and

narrower. They move in several different ways; in some one end swings backward and forward like the pendulum of a clock, others wriggle. The movement that seems to be wriggling is really the turning round and round of the spiral, just as a spinning-top does. Try the movement with a corkscrew held in place at tip and handle and quickly spun around, and you will see for yourself (Fig. 13). Some of the forms here (Fig. 13, *H*) are the little mischief-makers of which I was telling you in the last

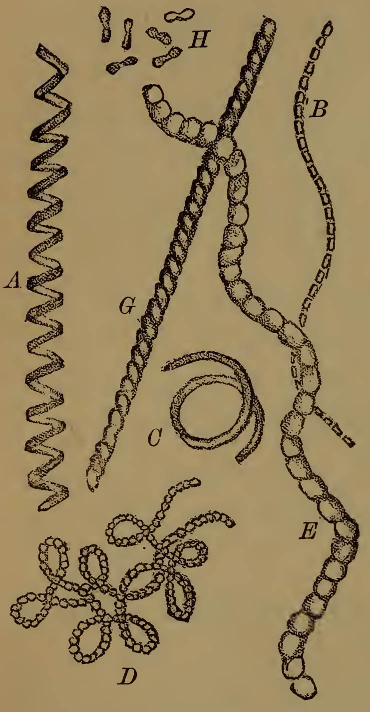


FIG. 13.—EEL-PLANT.
A, *D*, vibrios; *B*, *C*, *E*, *G*, spirillums; *H*, bacteria.

chapter, which cause meat to decay and spoil—bacteria they are called. A great many of them together, turning round in this way, naturally get tangled up into lumps. When one of these is placed on a sheet of paper, the separate little wrigglers often form a star-shaped figure which is very pretty.

If you have ever spent any time at the sea-shore, you must have seen queer lumps of jelly in the sand, and been told, if you were interested enough to ask, that they were jelly-fish. The vegetable world has its jelly-fish too. Sometimes floating on ponds, sometimes on damp or mossy ground, lumps of a clearish jelly will be found, very curious to look at and very mysterious in their coming. They are really a kind of water-plant. All through the mass are rows of round cells, like strings of beads, coiled up in great masses, and held together by the jelly that oozes out of them. A new colony is formed by the jelly melting up enough to let the strings

of cells get free; they begin wriggling, and at last get out of the jelly prison, grow and spread, and finally make a new colony like the one they came from. Sometimes a quantity of the dried-out jelly will be lying on a brick walk or some such place. No one would notice it in this state. With the first rain, however, the cells all swell up, and a lump of jelly appears as if by magic. These are sometimes called "fallen stars" by country people, who think they must have fallen from the sky.

Your watch-glass pond may perhaps contain another form which is interesting to watch without a magnifying-glass, but far more interesting with one. It looks to the naked eye like a little globe, not so large as a pin's head, of nearly clear green glass, with tiny specks of a deeper green through it. It goes rolling over and over and around in the water, not very fast, but pretty much all the time. Now let us put him under the microscope and see what he looks like. We

see globes of a deep green enclosed in a lacy net-work of a beautiful pale green color (Fig. 14, *A*). *B* shows this net-work still more magnified. You can see without my telling you that the net-work is made up of hundreds and hundreds of our little berry-fish fastened together by clear bands of a jelly-like material. The smaller and greener balls within the net are new colonies growing up to full size. When this happens, the outer globe bursts and lets the inner globes free, and so it goes on, each globe having globes within it like a Chinese ball puzzle.

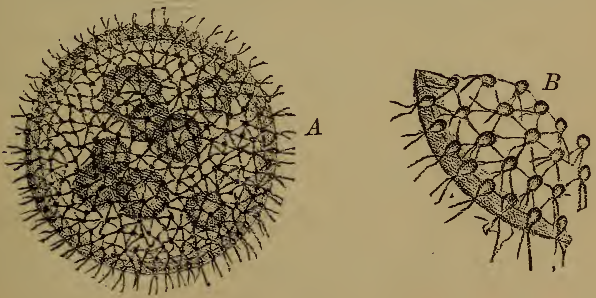


FIG. 14.

A, colonies of first-berry fish; *B*, part of the same magnified.

I wish I could give you a peep through my large microscope at the last kind of fish I am going to show you. These are a sort of vegetable shell-fish, and are found in all kinds of water—salt, fresh, and brackish. In the mountain brooks near West Point they grow in such multitudes that the beds of the streams are covered about one-quarter of an inch with them. Every stone and stick and twig is glistening with them. In other places they have been found in such quantities that the beds of rivers and the mouths of harbors have been choked up with them. The numbers you may get some idea of when I tell you that it takes sixteen millions of some kinds to fill a box one inch square, and these are a large kind.

Nothing in nature is more wonderful and beautiful, when magnified, than these shells. They are of the purest glass, of every imaginable shape, ornamented with the most delicate patterns. No drawing can give you an idea of

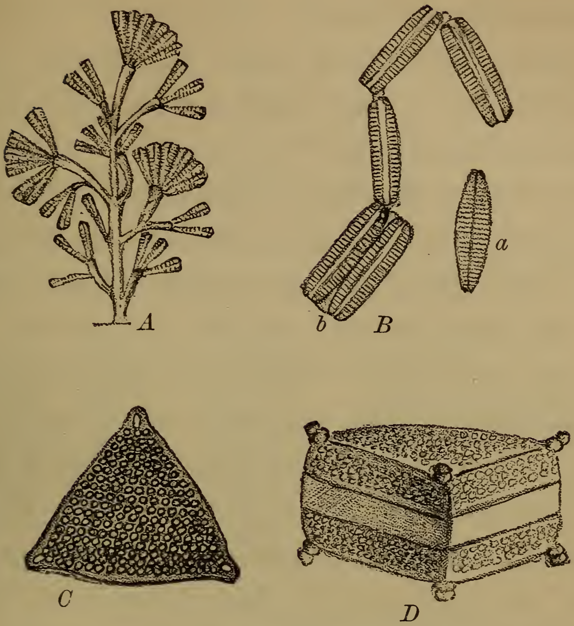


FIG. 15.—VEGETABLE SHELL-FISH.

A, on stem; *B*, fastened by corners: *a*, top view; *b*, 2, shell inside the band; *C*, top of new box; *D*, side view of box.

their great beauty. Here are a few of the shells. Some of them grow on stems (Fig. 15, *A*); some are attached together by their corners and live in long chains (*B*); others are free. They are of

all sorts of queer shapes. Like the "first-berry," they move about, but their movements are a curious jerking advance and retreat, which seems to have no sense in it.

Now look at Fig. 15, *C*. You see it looks something like a three-cornered box, *C* being the top and *D* the side view; the upper shell is fitted over the lower, just as the lid of a pill-box fits over the lower part. Inside is the jelly-like body of the plant. Like others of this family, the plant grows by the enlarging of living cells, which then divide up into two. This is easy enough in soft cells, but of course if it enlarged as we saw it do in the "first-berry," the beautiful glass shell would be broken to pieces. Now pay close attention while I try to explain how these curious little things manage to grow, and save their shells too. The jelly inside gets bigger; that pushes the lid up and partly off the bottom of the box. To keep any of the jelly from being unprotected, a band like a flat brace-

let of glass covers the edges, and grows wider as is needed. All this has been very carefully watched under the microscope. The jelly inside divides into two parts, and then one part of the jelly takes the old lid, and the other the old bottom for new lids, and inside the band each builds itself half a new shell (Fig. 15, *B*, *b*). So

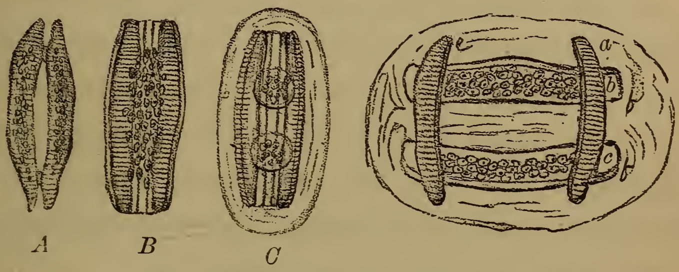


FIG. 16.—VEGETABLE SHELL-FISH.
A, *B*, *C*, successive stages in the formation of seed shell; *a*, old shells; *b*, seed shells.

two new shell-fish are made out of one; when this is done the band falls off, whole or in pieces, and leaves them each ready to begin this over again.

Sometimes two of the shells come near to each

other, and surround themselves with a kind of jelly (Fig. 16, *A*). After a while in the midst of this jelly appears a curious-looking shell (Fig. 16) entirely different from the ones it comes from. This is the seed of new shell-fish plants, like those which produced it (Fig. 16, *D*, shells *a a*, seed shell, *b*).

In the ages, long ago, when the world was making, these little plants had a good time of it. They grew in such quantities that their shells have made great beds of earth. The city of Richmond, in Virginia, is built upon such a bed, and millions upon millions of them can be found in a handful of the common earth.

Chapter V.

LICHENS.

It is not uncommon to find among animals a curious kind of house-keeping arrangement, by which they live together, each one helping to keep up the establishment, and all having equal rights. Oftener, however, we find one animal quietly settling down upon another, expecting to be supported in idleness. This is not only true of animals; it is equally true of plants. Some of the very smallest of them are as proud and independent as the largest; they busy themselves all day extracting their food out of the earth and air, earning their own living in a most praiseworthy way, and ready to lend a helping hand to others. The "dead-beats" of the vegetable world are most commonly found among the lower classes—the fungi.

You remember, in studying the fungi we found that one thing—the principal thing—which marked their difference from the green plants was that they are obliged to feed on what has been some time a living substance, whether vegetable or animal. The yeast-plant and moulds and mushrooms feed upon dead material, that which is no longer alive; but there are other fungi that prey upon living things—some of these we have already studied (Figs. 6, 7, 11) in the chapter on the fairy fungi—such as the grape fungus, the potato blight, and the silk-worm fungus. These forms of fungus life seem in most cases to be a kind of disease. But there are still other forms which are even more curious.

Have you not, hundreds of times, in the woods noticed how old tree trunks and twigs, particularly dead ones, were covered with a curious crust, sometimes gray and sometimes greenish in hue? Occasionally you have found them bright orange, and again holding up coral-red cups to

the sun and rain. These are not *mosses*, as you often hear them called. In fact, they have no correct ordinary name, and so get their botanical name of lichens oftener than any other.

One of the most singular things in the study of all plants are these same plants, and it took a great many long years of study to find out their ways. A lichen is really a peculiar kind of a fungus, growing on and sucking its nourishment out of a little green water-plant, which manages to support both itself and its "dead-beat" neighbor. For a long time the little green cells that flourished so bravely in the clutch of the lazy giant of a fungus were thought to be the fruit of the fungus. After long studying and examining, some keen-sighted botanist saw that the green cells were no more nor less than our little "first-berry," being eaten out of house and home by his lazy visitor. He collected the green cells of the plant, and, to test the matter, he sowed them, and watched what became of them; they grew

apace, and when they came to move about he found that he was not mistaken: they were, sure enough, the "first-berry."

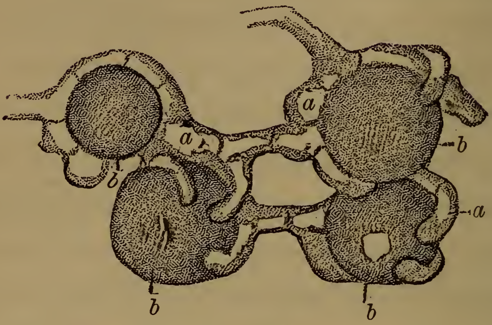


FIG. 17.—LICHEN MAGNIFIED.
a, fungus; *b*, host.

You see in Fig. 17 how the twining arms of the lichen, *a*, embrace the "first-berry," *b*, and push their way into the very heart of the cell to take away its food. For some reason it does not overpower and kill its little host—possibly it may in some unknown way pay board in services, but nobody has ever found it out if such is the case—though it is a fact that some of the

tiny plants so preyed upon, instead of being hindered in their growth, seem to be rather stimulated by the demand upon them.

All these lower forms of life, including the fungi, odd fish, and lichens, are called by a Latin name meaning that the plant is all leafy. They have no distinct stems and roots, they all seem to be just something like a leaf. In lichens this leafy crust is called a thallus—it has no correct common name.

The thallus creeps on chips of decaying wood, bark, or small branches, diving down into the cells of the green plant below to feed itself, and sending up into the air the little cup or heads, which are its fruit. Some of the gray, woolly lichens that cover twigs growing near the seashore, or down in mossy dells, have what seem like stems; but they are not true stems, the cells inside are different from stem cells (Fig. 18) and like those of the leaves. We have to learn, in studying nature, "not to judge according to ap-

FIG. 18.—WOOLLY LICHEN.
(*Usnea barbata.*)

pearance, but to judge righteous judgment." It is by the *lives* of these little creatures, not by

their mere outward appearance, that we know their real character.

Lichens are good things to study in winter, for you can find them when other plants are having their long sleep. They grow everywhere, and on pretty much everything that has crevices in which their host can find moisture.

The "first-berry" is by no means the only one of the "odd fish" which are hosts to the lichens. The vegetable jelly-fish, the red snow-plant, and others answer the same purpose. But whatever the host is, you cannot help feeling that he is ill-used. Sometimes one is almost smothered in the embrace of his ungrateful visitor and guest; sometimes another is fairly sucked dry by these sponges; but the plucky little things manage to live somehow and bear the burden of life.

Some of the lichens contradict the old saying that "beggars must not be choosers," for they will not live on any host but a particular one

which suits them. Others are not so particular, and will take to any one which will afford them nourishment.

Occasionally, among the hard dry growths that are the commonest forms of lichens, we find a kind that is like cold, clammy flesh. It grows in cushion-like masses. In these forms the poor little host is scattered in bunches through the

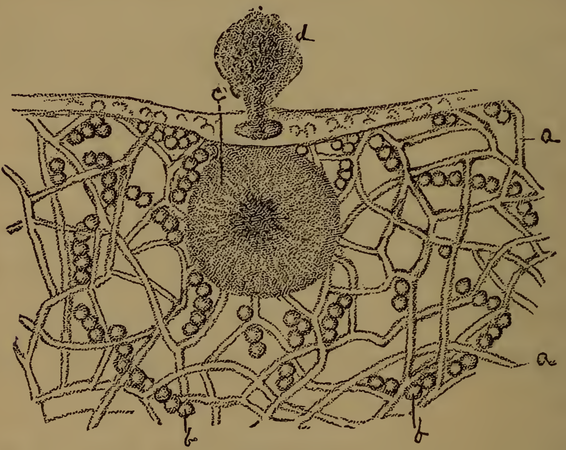


FIG. 19.

a, the fungus; *b*, the host; *c*, the spore cup from which the spores are escaping; *d*, spores.

(*Collema.*)

fleshy mass, or runs through it like strings of glistening beads (Fig. 19, *b*).

Lichens, like some plants higher in the scale of life, grow from *spores*. These produce new plants as seed do, but they are not seed. Seed,

FIG. 20.—ENCRUSTING LICHEN.
(*Parmelia.*)

as you will see when we come to them, are always made by the partnership of two entirely different cells combining together. Spores are more like a little bud growing out of the plant, and when it is ripe, getting loose from the place where it

grew, and being scattered on the ground by the wind or the rain. They grow usually in some sort of cup, which holds them safely till they are ripe and free (Figs. 19 and 20).

It would not seem that such sturdy little beggars and persistent sponges would be of much use in such a busy world as this; and yet if it were not for them a large part of the world would be without inhabitants. All Lapland, you know, is inhabited by people whose living depends on the reindeer. In our climate we can scarcely imagine how people could depend so upon any one kind of animal. But the people there have nothing else; they eat the flesh, and drink the milk of the reindeer; their clothes are made from his skin, their tools are carved out of his antlers; his sinews supply thread, his bones, soaked in oil, they burn for fuel. Living, he is his master's horse and mule, carrying him and his belongings from place to place. The Laplander's whole mode of life depends upon these tiny little plants

FIG. 21.—REINDEER LICHEN.
(*Cladonia.*)

(Fig. 21), for when the reindeer have devoured all that is growing in one place, the Laplanders move bag and baggage, where they can find some more.

In the short, hot summers the reindeer can get the fresh shoots of certain trees, but in winter there is nothing but the lichen under the snow. Besides being the only food they can get to eat, it seems to be necessary to them. When reindeer are brought to temperate climates as a show, it is found necessary to feed them on these lichens or something of the kind, or they will not keep well and hearty. As food the lichen has another advantage, that it takes a great while to digest, and a meal will last for a long time, enabling the reindeer to take long journeys over the frozen snow-covered ground without a fresh meal.

There is one kind of lichen which grows in great quantities in some parts of the far north countries. This is called the *tripe de roche*, or rock tripe, because it looks a little like tripe and because it can be eaten by men. Arctic travel-

lers, caught by the ice in these northern countries, have been kept alive for weeks, when they had no other food, by these lichens. It is one form or other of these tiny plants, which we scarcely even notice, that saves great regions of Arctic country from being a desolate no-man's land from end to end.

Chapter VI.

PLANTS AND ANIMALS—THEIR DIFFERENCE.

If the question were put to you suddenly, "What is the difference between a plant and an animal?" how do you think you would answer? Stop a minute, and think. Do not be satisfied with saying that a plant has leaves, and an animal has not. Look deeper, and answer more thoughtfully. There are many plants which have no leaves, nor roots, nor flowers; this you know very well, for the only plants we have examined so far have had none of these things, and there are some animals which seem to have all of them, as you may see by looking at Figs. 22 and 22*a*. In some cases they are so much alike (Figs. 23 and 24) that it has taken the most careful study to decide whether they are plants or animals.

FIG. 22.—ANIMAL SEAWEED.
(*Plumularia.*)

Look up into the bright blue sky, and then down at the solid earth beneath your feet—you do not find any difficulty in telling, without taking a moment to think, which is sky and which is earth; but if you are so happy as to live in the wide open country, or near the sea, or on a lofty hill, look off and off and off until you see only the delicate blue haze like smoke which divides the heavens from the earth. You can often see the same thing by looking from the upper windows of a high house.

FIG. 22*a*.
(*Plumularia.*)

You will find that many and many a time you cannot tell which is earth and which is air.

Just so it is in the world of nature. You may look at a group of cows standing under

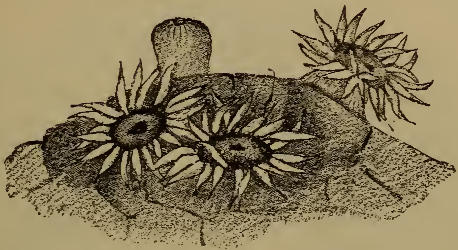


FIG. 23.—ANIMAL.
(*Coral polyps.*)

the trees, or watch the merry little grasshoppers skipping about in the weeds, or catch a bee at his early drink in a morning-glory bell, and you would laugh if anybody asked you if you could tell the animal from the plant. But get far enough away from these common things, and study the animals and plants that need your microscope to see them, and you would find things so much alike that you could not tell

which was which. Many of these plants have no roots nor leaves, no flowers nor seed, and many of the animals have no heads nor legs,

FIG. 24.—VEGETABLE.
(*Mesembryanthemum.*)

no eyes, nor mouths, nor stomachs. In Fig. 25, *a* is a plant, and *b* is an animal. Now how do you suppose anybody knows this? People who study these things do not *guess*—they *know*.

The real difference lies in what these tiny little creatures do, not at all how they are formed.

About three-fourths of all the kinds of sea-weed, for instance, are found to be animal—not one animal, but a colony; the other fourth are vegetables. All these used to be considered vegetables; so did the sponge, and the coral, and the sea-anemones, and they are all now known to be

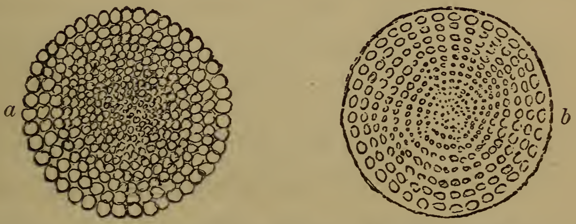


FIG. 25.—WATER PLANT AND WATER ANIMAL.
(*Diatom.*) (*Foranimifer.*)

animals. Every time you play the game of "Twenty Questions" you have to think and decide whether the particular thing you have chosen is "animal, vegetable, or mineral." Have you any notion what makes the real difference between them?

I imagine that, sooner or later, you will think and say the difference is that animals can move and plants cannot. That might have been a very sensible conclusion if you had come to it before you had studied anything about the curious odd fish in the vegetable world. It is not correct, you now know, for plants do move, some of them very much as animals do; others, and the greater number, in another way: which all seems very wonderful, and which I want to talk over after a while in the chapter on Climbing Plants.

What makes the real, deep-down difference is this: Plants can live on mineral matters alone, on earth and water and air, and these things they can change into their own flesh and blood, their stems and sap and fruit. Animals can only live on what the plants have already turned from dead into living material. We need water—that is a mineral—and salt and air, which are minerals too, if we are to keep alive and well. But we cannot live on these things alone:

we should soon die if we had no food; and all really nourishing food, all that keeps our blood warm and makes us grow, has once been vegetable. Not one bird or fish or animal, not one single human being, could ever have lived on this earth, in the air or in the water, if the plants had not come first, and prepared the earth for us to live in.

These are "sure enough" fairies that are forever working their wonders for us. The roots, like elves, grope down in the earth, and gather its treasures; the leaves stretch out into the air, and gather its riches, and out of what they have collected they weave the beautiful flowers, and delicious fruits, and golden grain.

I should like to make very clear just the way they do this; it is very wonderful and beautiful to study how they work their spells. First, the root, as we shall see, armed with its little helmet, bores its way down into the earth. If it finds no water or damp earth it soon wilts and dies, but

if it finds a wet place it begins to soak up moisture. Besides the water, it sucks up all the parts of the earth that are dissolved in the water. The water it *must* have, and it will manage to live a while on that alone, as many starving men have done; but it cannot live so very long. Poor ground means ground that has little or no plant food in it.

You know, if you ever did any gardening work, that you can stick a cutting of geranium or begonia into pure sand that has no nourishment at all in it, and that if you keep it well watered the cutting will strike out roots and bear leaves. This is, in fact, the best way to start cuttings, for mould is a little apt to rot the stem, but the sand preserves it. After a while the baby plant is tired of doing nothing but sucking water, and cries for some stronger food. Then you must put it into rich earth, still giving it plenty of water. The roots, like the baby's stomach, will at first be satisfied with a very milk-and-

watery diet, but after a while it must have a strengthening soup.

The roots bring the plant a good deal, but the leaves are the principal feeders. Every leaf and stem is supplied with millions of little mouths, which are usually open, breathing in the air and breathing out moisture and the gases it cannot

FIG. 26.—LIVERWORT MOUTH OR ROOM.

use. These mouths bring both food to nourish and air to sustain the plant. A fish keeps itself alive by sucking the water it lives in all the while through its gills. It gets out of the water whatever it needs — air and some food. The plants are like fishes; their water is the great ocean of air that lies on the surface of the earth. They

draw it in through their mouths, take out of it all they need, and then breathe the rest out again.

In Fig. 26 you see a piece of a liverwort leaf

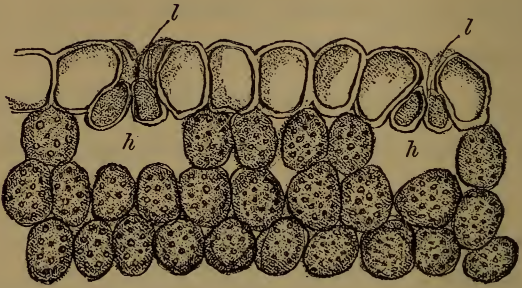


Fig. 27.—Plant Mouth.
h h, hollow of mouth; *l l*, lips.
(*Iris.*)

cut down through the mouth, and in Fig. 27, another kind, a blue-flag. In the next chapter (Fig. 30, *b*) you see some of the mouths of the corn-plant; this is the outside view, as you see your own mouth in your face when you look in the glass.

Air is a curious mixture. It is a gas made of several gases stirred together as you stir tea and milk and sugar. One of these gases is called

oxygen (don't be afraid of the hard names); that is what keeps us alive. I won't give you the name of the next, because it is only used, like the milk, to weaken the tea. The third is a very disagreeable and dangerous gas, called *carbonic acid gas.* It is this last that makes your head ache in a crowded room or car. This is what you hear of every now and then as *choke-damp*, which suffocates people down in mines and deep wells. It is this which comes from burning charcoal, and makes it sure death to burn it in a closed room. There is very little of this dangerous stuff even in close air. Carbonic acid gas, though so poisonous, is made up of two things, which are very good and perfectly harmless when they are separated—carbon and the life-giving oxygen. Carbon is coal, or something like coal. United together, these two harmless things make a dreadfully dangerous one, just as innocent saltpetre, sulphur, and charcoal unite to form the deadly gunpowder.

Now notice how beautifully plants and animals are made to live together and help each other. Animals breathe in the air, and help themselves to the oxygen which keeps them alive, but breathe out the deadly carbonic acid gas. Plants breathe in the air, separate, by some wonderful power of their own, the carbonic acid gas into carbon and oxygen, help themselves to the carbon and breathe out the oxygen. What plants consume we throw away as useless, and what plants breathe out sustains our life. That is the reason why the country is apt to be so much more healthy than the city. The air that is poisoned by people and fires becomes purified by plants.

Unlike the fairies of the story-book, who do all their good deeds by night, these little plant fairies work only by the light. The sun is their master, and his first ray is their call from sleep. They set to work in a minute, separating the dangerous carbonic acid gas into carbon and

oxygen; and while they use the carbon and grow by it as you do by your food, they are giving back the sweet pure oxygen to the air. All day long they are at their good work; but when the sun sinks behind the hills, they do not need any sunset gun to tell them their time of rest has come. They drop work at once, and drop their fairy ways; they begin right away to behave as the animals do—to breathe in oxygen and breathe out the hateful carbonic acid. That is the reason it is not healthy to sleep in a room with flowers at night, though they are so good to have in the daytime.

We owe our lives to the plants—the food we eat, the pure air we breathe, as well as much of the rain that falls from heaven. They are ministering angels, and the loving, tender, heavenly Father has appointed them their work to do—to beautify the earth and purify the air under the guidance of the glorious sun, which He has created and which He keeps in its appointed path.

Chapter VII.

THE THIRSTY FLOWERS.

Fill a glass with water, and let a piece of common tape or a strip of muslin hang so that its lower end shall dip into the water, and then notice it; the liquid creeps slowly but surely up the strip. If the end which you have in your hand is dropped on the table beside the glass, the goblet may be entirely emptied, the water running up over the edge of the glass before it runs down again. This behavior of water would seem very queer if we had not noticed something of the kind all our lives. It is caused by what is called capillary attraction. Whenever one part of a material full of fine openings which lead through it is dipped into a liquid, the fluid runs through the whole stuff, even if it has to run up-

ward. Try a lump of sugar: put one corner into your cup of tea or hot milk, and watch it soak the lump through. The burning of a lamp is upon the same principle. The wick serves to carry the oil from the globe of the lamp to feed the flame. As soon as the oil gives out, the light fades and dies away.

Every part of a plant needs water; it must be close around every little cell. These cells are the tiny queer-shaped bags full of liquid that are packed close together, and make up the leaves, stems, and flowers of plants. In Fig. 28 you see the cells of a leaf of geranium flower, and one of sorrel or sour grass, which, if you are like the children I know, you have many a time eaten to get the pleasant sour taste. Well, every one of these tiny cells must be kept wet all the time, or the plant will die. The only way we can think of that water could get up into the leaves and flowers from the earth is by capillary attraction, as it runs up the strip of muslin. And if it were

not for this singular behavior of water, the only plants in the world would be those that grow in the seas and rivers and lakes. The land would be as barren as the desert of Sahara.

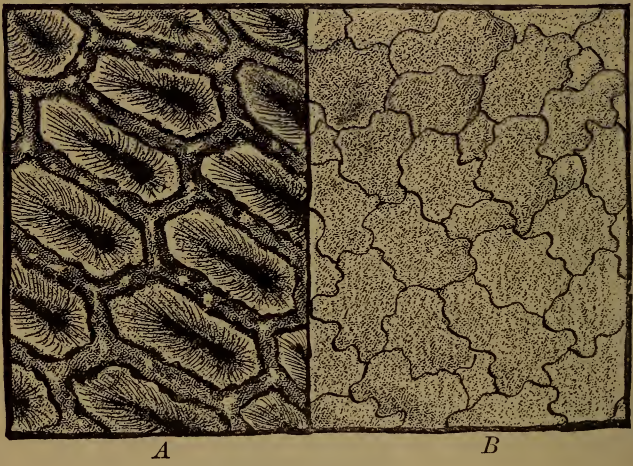


FIG. 28.—CELLS.
A, leaf of geranium flower (*Pelargonium*); *B*, leaf of sorrel (*Oxalis*).

Now try to think of some plant with all the earth away—a tree, for instance—and you will see that it is a sort of double growth; that there is an upside-down tree in the ground, with its

trunk and branches and twigs, as well as one above the ground. The underground twigs do not bear leaves, but each one of them wears on its head a little cap or helmet to protect the tender growing part from being injured as it pushes its way through the hard earth. The most important parts of a tree are those that seem of least consequence, the rootlets and the leaves. These are to the tree what our mouths and stomachs and our lungs are to us; the roots are the feeders, and the leaves the breathing apparatus of plants.

As the underground tree grows, the tender little roots push their way down into the darkness and cold of the deep soil; they find their way around stones and through great clods of earth, anywhere and everywhere, until they get their little noses into water or damp earth, and then they begin to suck. Sometimes it is only pure water that they take up from the earth, but generally it is a sort of broth—water with plant food dissolved in it.

The roots and stems and leaves are all full of little passageways running upward, and branching and dividing until they reach the leaves. Fig. 29 shows a corn stalk cut across. You see some roundish holes, marked *a;* these are the ends of tubes that run through the stalk. When the corn begins to grow, take a stalk about two feet high, and cut it across; you will see little white spots all over the cut place. This figure is

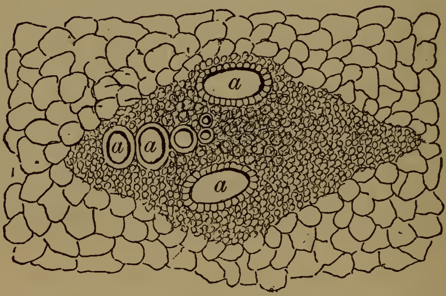


FIG. 29.—CORN STALK CUT ACROSS.
(*Zea.*)

one of those white dots magnified. Figure 31 is the same dot viewed sidewise.

When these tubes come into the leaves, they

open into little spaces just under the outside skin of the leaf. These spaces are like the hollow of a mouth, and each one has generally two lips that

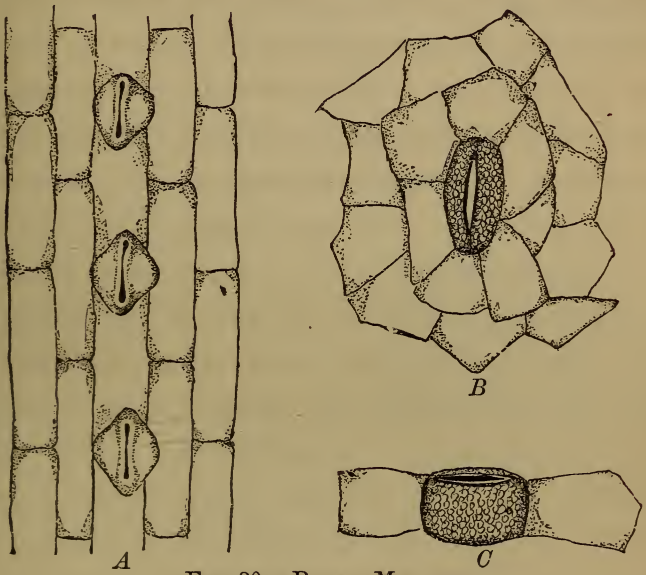


FIG. 30.—PLANT MOUTHS.

A, corn leaf with three mouths; *B*, bean leaf, with mouth; *C*, mouth seen sidewise.

(*Zea.*)

are sometimes open and sometimes shut. Through these tiny mouths (Fig. 30) the plant breathes.

It draws in air, and it sends out, as you do, a mixture of air and water. If you want to know how much water there is in your own breath, try holding a piece of cold glass before your mouth.

Plants are not wasteful of the water so necessary to their lives. What they do not use they give back to the air from which it was received, as we make our thank-offerings to God for what He has given us. The roots suck up the water, and each little cell takes a drink as the water passes it, and hands on the rest to the cell just above it. And so the water takes its course, supplying each thirsty cell with drink as it passes, spreading through every part of the plant until it reaches the little mouths. And there all that is left is breathed out in a fine steam which you cannot see until it touches some cold substances, and is turned into water again (Fig. 31).

Some one who wanted to know exactly how much water was given back to the air by growing plants, carefully examined a number of them,

and found that a single sunflower plant gave off in twelve hours a pound and a quarter—enough to fill nearly to the brim three common table goblets. Another plant, the wild cornel, was found to breathe out more than twice its own weight of water in a day and a night.

In order to find out what parts of the flowers were the principal water-carriers, a deutzia, one of our most delicate and beautiful spring flowers, which you probably know by sight if not by name, was put into some very blue water, colored with a mixture of what is called aniline, and in a little while every vein of the flower was a beautiful dark blue. The poor little blossom was, however, poisoned with its dose, and wilted away in a few minutes.

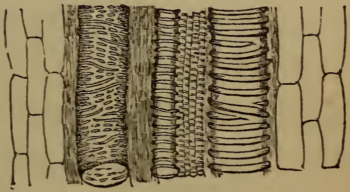


FIG. 31.—WATER-CARRYING TUBES. SIDE VIEW OF CORN-STALK TUBES.
(*Zea.*)

The quantity of water that plants breathe off is so great that it makes an entire change in the climate when forests are cut down. Plants, like grasses and small weeds that grow on the surface, of course do not make the same difference, for their roots only go down a little way. But trees are very important: unless the air is kept damp by the sea or some large body of water, it depends very much upon trees for its moisture. Where there are no trees, the rain that does fall sinks into the earth, and runs away in little underground currents, and is lost. There are no deep roots to stop this waste, to suck up the water, and restore a large part of it to the air.

In places where the rainfall is frequent, and the air is always kept soft, plants may be as lavish of their water as we are in the great cities where the supply never fails. Plants growing in such places very often keep their mouths open all the time. If this were the habit of those which grow in very dry places, they would soon perish of

thirst. On the high Western plains beyond the Mississippi only a few things are able to live. Among these are some kinds of cactus plants,

FIG. 32.—CACTUS.

which you have probably seen in greenhouses or as window plants (Fig. 32). The reason why they manage to grow such bulgy leaves and fat stems where there is so little moisture, is because this

plant is so very stingy of its water. It hoards it up as the travellers over the great African deserts do, knowing how hard it will be to get more. The roots of the cactus suck up every drop of water they can find, and the leaves keep their millions of little mouths tight shut so as to hold it all. Only such plants can grow on these plains as are able to do with very little water, or else are wise enough to hoard up all they can get. This water we have been talking about is not sap—that is the blood of the plant—but it is like the water we drink, and which not only helps to make the blood, but keeps all of the parts soft and moist so that it may live. The largest part of every living thing is water. It is not without good reason that the Bible so often speaks of the *Water of Life*, for without water no life could exist for a single hour.

Chapter VIII.

PLANTS CAUGHT NAPPING.

As we come to be more intimate with plants, and know all about their doings and see into their daily lives, we continue to find things which remind us of animals. Plants, we already know, eat and drink and breathe and move. Besides all these things, they sleep; and they must get their sleep regularly, or they lose their health completely.

Nowadays inventors spend their lives trying to find out useful things—things that will make life easier and pleasanter: such things as steamboats and railroad cars, and telegraphs and sewing-machines, and a thousand others of the same kind. In old times all the inventions were made to compel men to believe this or that religion by

the use of ingenious tortures. There was no end of different kinds of suffering which poor miserable people who had their own ideas on religious subjects had to suffer. Among these was the horrible torture of keeping people awake night and day till they died. Such dreadful things are no longer practised on people in Christian lands; but many and many a poor plant dies and makes no sign from just this cause.

People can sleep where there is a light in the room; hardly so sweetly and soundly, I think, as they can in the darkness; still they *can* go to sleep in the light. But plants cannot. Until the darkness comes they go on working and working, no matter how tired they are, till the plucky little creatures drop in harness and die. The work they do, I have already told you, is to separate the poisonous carbonic acid gas of the air into two useful things—carbon for themselves, and oxygen to keep people and animals alive. But they need rest as much as you or I do.

Working night and day is too much of a strain, and finally their health breaks down and they die.

Many plants are not contented merely to stop working. That does not give them all the rest they need. The leaves want to lie down or to hug close to each other, in order to sleep comfortably and rise refreshed. If you notice carefully a spray of locust leaves, for instance, by daylight, you will see it look something like this (Fig. 33). I drew this, one bright August day, just as it grew on the tree. The leaves are all spread abroad to catch the light and the breezes. The thou-

FIG. 33.—LOCUST BRANCH AWAKE. (*Robinia.*)

sand little mouths are open, breathing in the air. In the evening, after it had grown dark, I went out and drew the same spray asleep (Fig. 34). There was just light enough for me to see, but not enough to wake the locust leaves. There they lay, hugged up to keep warm, their little mouths pressed close against each other.

Fig. 34.—Locust Branch Asleep.
(*Robinia.*)

It may seem as wonderful to you as it did to me when I first learned it, that all your lives the plant and trees around you had been going to sleep and cuddling up in this way, and you had never noticed or known it. When you think of it, it is not really so strange, for most of the time that

the leaves are asleep you are asleep too, and any light which under ordinary circumstances would show them to you, would keep them from going to sleep. In order to see these sleeping leaves you would have to take a lantern and go out after it was dark, and examine sprays which you had particularly examined by day, to see just the difference.

Fig. 35.—Sensitive Plant Awake.
(*Mimosa.*)

The young leaves, like young babies, sleep more and cuddle up closer than the older ones do. I examined a great many plants, and found no other very common plant more interesting than the locust-tree. Some wistaria

leaves, especially the young shoots, not only close up but turn over on their stems to get their rest.

Fig. 36. — Sensitive Plant Asleep.

The most remarkable plant of all that I examined was a mimosa-tree, or sensitive plant, as it is often called (Fig. 35). This tree, however, grows full thirty feet high. In Virginia, where I made the drawing, you can sit and watch the branches against the evening sky; and as the twilight falls, the entire tree seems to be thinning out until it looks as if the season had gone backward and we were looking at the tree in its early spring dress of delicate sprays (Fig. 36). It puts one in mind of Keats's beautiful line, when speaking of a lovely girl going to sleep—

"As if a rose should shut and be a bud again."

It sometimes happens that plants which usually close their leaves when they sleep are very heavily shaded during the day. When this is the case they do not seem to be much affected by the darkness of the night, and do not change the position of their leaves. It would seem as if they had been half asleep all day, and so had spoiled their night's rest. Darwin tells us of a plant which he says he watched carefully, and for two nights after having been violently shaken by the wind it did not cuddle down to sleep. It was probably too much excited to rest properly.

This movement of sleep is so much affected by the presence or absence of water, which you remember is the cause of all vegetable movement, that if the ground in which the plant grows is allowed to get very dry, or the air becomes extremely parched around it, it makes no sleep movement at night. The "touch-me-not" and mallow are affected in this way by drought. Mr. Darwin tried to see how long a little plant

he had from Chili would live without water. He watched it for three weeks without giving it a drop to drink. Its leaves became dry and dusty, so that some of them would drop off from the stem every time he shook the pot. The earth about the roots became like the dust on a summer road. The leaves that remained on the stem did not close in sleep at night. Finally, at the end of twenty-one days, he watered the earth and sponged off the dry and thirsty leaves. The next morning it seemed as fresh as ever, and when night came it nestled itself down comfortably to its rest.

Some plants will go to sleep if they can make themselves comfortable; while if they are very much chilled by exposure to the cold night air they will not make a sleep movement. There is something almost human in all these freaks of wakefulness in the plant world.

In some plants the leaves stand up to go to sleep, as horses do; in others they droop down,

or lie close to each other like little children. One kind of clover which has a yellow blossom

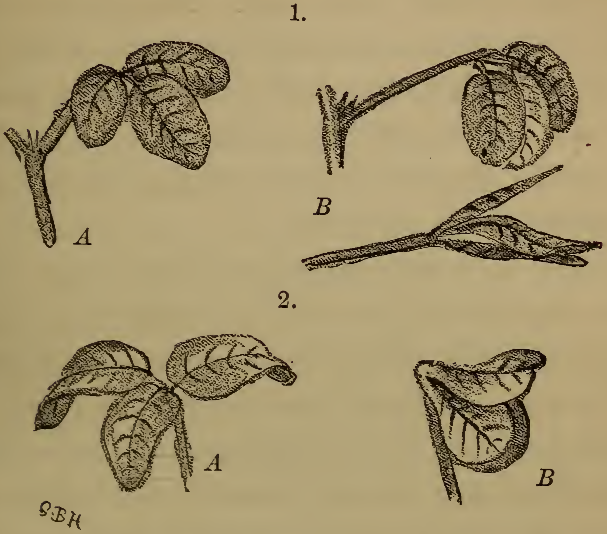


FIG. 37. { 1, YELLOW CLOVER..........*A,* awake; *B,* asleep.
2, COMMON WHITE CLOVER...*A,* awake; *B,* asleep.
(*Trifolium.*)

sleeps very curiously (Fig. 37); it has, as of course you know, three leaflets on each stalk. Each of the three twists itself around through the quarter of a circle, turning one of the side edges to the

sky. Two of the leaflets — the side ones — face towards the north, one a little to the east of north, the other a little to the west. The middle leaflet turns sometimes eastward, sometimes westward; in doing so it twists itself over so as to protect its own upper surface and one of the other leaflets at the same time. The common white clover also sleeps very curiously.

There is a very singular plant which bears three leaves on a stem, the middle one being large, and the other two long narrow leaflets which stand straight out from the stem just below the bottom of the large central leaf. They look like a pair of oars poised in the hands of a rower when he is waiting to dip them into the water. When this plant goes to sleep the small stem which holds the leaf stands straight up, and the leaf turns directly down flat against the stalk. The plant hardly looks like the same thing awake and asleep.

Besides the sleep movement this plant has

some wonderful motions, which seem to be without any particular reason, and to come generally from change of temperature. Mr. Darwin put the stem of one of these leaves into some water cool enough to be pleasant to drink, and then changed the water for some about as warm as lukewarm tea. The leaflets began to move, and in a minute and a half had made a complete circle. In very young plants of this kind the leaflets jerk all the while, very much as a baby kicks its legs and moves its arms, without having any particular reason for doing it.

When leaves get sleepy they do not sink steadily and quietly down. There is nobody to take them and lay them down to sleep when they feel drowsy, so they go off by themselves in a slow sort of nodding motion. Fig. 38 shows the path

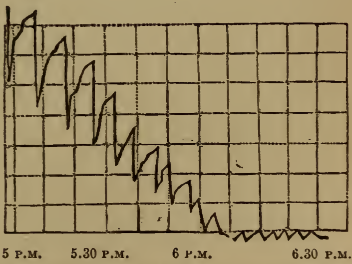


Fig. 38.—The Path of the Nod.

that one of these little sleepy heads moved over before it went off sound asleep.

The cause of all these movements is, as we shall see when we study the movements of growing and climbing plants, the shifting of water from cell to cell, but the reason for them is the same which makes two little children sleeping side by side draw closer together when they feel chilly, and nestle down together in the bed. The warmth of their bodies then is not lost, but passes from one to the other.

Chapter IX.

LIVERWORTS.

One beautiful September day I started out, basket in hand, to hunt for some curious plants that I had been reading about, and which had interested me very much. I had often noticed, as you have probably done, curious flat leaves, with curled-up edges, growing on damp paving-stones or around a spring, clinging close to the stones or wet ground, and carpeting them with a mat of rich dark green.

As soon as I began reading about the liverworts I recognized my old friends at once, and was anxious to see them again now that I knew something about their ways. A friend who was interested in my studies promised to show me the way to a spot where they grew, and this September day was set apart for the excursion.

After leaving the street cars we turned down a side path and entered a deep cut, and in another minute a great wall of uneven rock and earth stood in front of us, covered from top to bottom with the most exquisite green. Mosses clung close like a rich velvet mantle, ferns reared their delicate fronds, tiny weeds fresh from the continual sprinkling of a stream of water which trickled over the rock grew in all the little crannies, and close around a spring which had hollowed out a small basin for itself in a ledge of the solid rock grew the liverwort.

Besides what I had seen before in the liverworts I now found that the leaves were spotted all over with diamond-shaped markings of a darker green, each of which had a dot in the centre, and that they were covered underneath with a number of white glassy hairs, which laid hold of the rock, and glued the leaves down so tightly that it was very hard to loosen them.

There were three other kinds of outgrowths

upon the leaves, which I want to show you when we have done examining the leaves themselves. Fig. 39, *a*, is a leaf which I brought home to draw

FIG. 39.—LEAF OF LIVERWORT.
a, pocket disks; *b*, seed disks; *c*, nest.
(*Marchantia.*)

for you; *b* is another from a place close by. Fig. 40 is a piece of the same leaf magnified. You see the diamond-shaped spots plainly in this, with the little dot in the centre. Now I want to make you understand clearly the meaning of these spots and their central dot.

Just imagine that this irregular piece of leaf is a large low house, only one story high, made up of quantities of little rooms placed side by side, and with no entries or passageways between them. The under side of the leaf is the floor of the house,

the top is the roof, and the diamond-shaped spots all over the top are the roofs of the separate rooms; each spot is a single roof, and covers in one room. The dot in the centre is a wonderful little chimney that leads out of the room into the

FIG. 40.—PART OF LEAF OF LIVERWORT, MAGNIFIED.
h, root hairs.
(*Marchantia.*)

open air, and keeps it fresh. These chimneys are for the same purpose as the lips we have been examining in the corn-plant; the rooms are the hollows of the mouths, but instead of two simple lips opening into a hollow the liverwort has this cu-

rious chimney-like opening and looks so little like a mouth that I did not want to make it harder to understand by calling it so. These rooms have no doors or windows; they have only these chimneys, for their inhabitants never want to come and go; they only want light and air, and these they get through the chimneys. We have been looking at the liverwort rooms from above; a good magnifying-glass will let you look right down the chimney's throat into the rooms, and see the little inhabitants. Now I want to take off the front of one of them as you take off the front of a baby-house to look in. Fig. 41 is a room cut in this way, though this is cut right down through the middle, so that the chimney is sliced in two, and you may see how it is built.

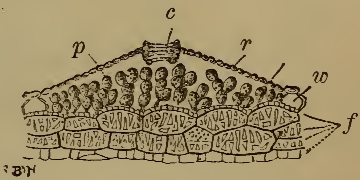


FIG. 41.—LEAF OF LIVERWORT CUT THROUGH ONE ROOM AND FLOOR.

r, roof; *c*, chimney; *w*, wall; *p*, plants growing inside; *f*, floor.

(*Marchantia.*)

The floor, *f*, is very thick, made up of three or four rows of cells; the walls (*w*) are only one cell deep; the roof (*r*) slopes up from every side towards the chimney (*c*), which is in the middle. The chimney, as you see, is built of rows of cells, one laid on top of another, just as the bricks are laid in our chimneys. The inhabitants are like the inhabitants of a greenhouse; they are queer little plants, something like the cactus plant so common in greenhouses or as a window plant.

The liverwort is a plant that seems to be all leaves. There is no regular stem, but the leaves grow on and on, one out of another; the roots (*h*) are the little glassy hairs that grow from the under part of the leaf. What takes the place of a flower—that is, the part that produces the seed—also grows out of the leaf. I hope you noticed in Fig. 39, *b*, the odd little umbrella-shaped things that came out of one, and the blunt, clumsy scalloped clubs out of the other, *a*. If not, you may

look back now and see them, for they are very curious little things.

The first we will examine under the magnifier. Fig. 39, *b*, is like a little umbrella deeply scalloped about the edge. In Fig. 42 you may see it in two

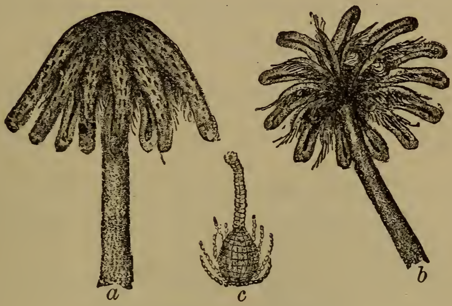


FIG. 42.—SEED DISK.

a, ***b***, **seed disks, two positions ;** ***c***, **vegetable bottle.**

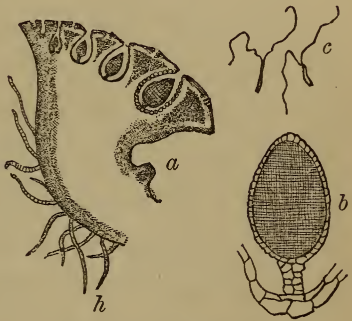
(*Marchantia.*)

positions very much enlarged. No drawing can give you the least idea how beautiful this is under the microscope (Fig. 42, *a*); the delicate green spotted with a deeper tint of the same color and from beneath lovely irregular fringes, which look as if they were made of glistening spun glass.

When you turn it over (*b*) you see nestling between the bright fringes a little round body like a pea in its pod; this body comes after the seed. If I had looked for my liverwort earlier I would not have seen this pea, but would have found something even more singular, which comes before it, as the flower comes before the fruit. We cannot talk about things without having some name to call them by, and as the names the botanists give these things are very long and hard and puzzling, we will name them for ourselves, and call these long scalloped umbrellas seed disks, for they grow the seed.

After the seed disks have grown, down between the fringes a tiny bud sprouts, which, when it is complete, is an odd, pretty little vegetable bottle with a ball in the middle (Fig. 42, *c*), reminding one of the water-bottles with ice frozen in them that we sometimes see at restaurants. When the bottles are full grown the neck peeps out from between the fringes, waiting for something.

Now we will have to go back, as they do in the story-books, and see what the bottles are stretching out their little necks for. On the other growths (Fig. 39, *a*) you see some queer little toadstools which grow underneath the leaf, and curve around upward till they stand straight up; these usually grow on another plant near by the seed disk, and while one is growing the other is doing the same thing. Now look at one of these little toadstools (they are not really toadstools, but they look like them). This was cut with a sharp razor right down through the middle, as we did the tiny room of the leaf, and you are looking at it sidewise.



FIG, 43.—WHIP-CASE.
a, pocket disks; *b*, egg-shaped body; *c*, whips; *h*, root hairs.
(*Marchantia.*)

You see (Fig. 43, *a*) that it is all full of little

pockets, and that standing on end in each pocket is something like an egg. Fig. 43, *b*, is this egg enlarged still more.

Each of these eggs is like an immense prison, with hundreds of cells built story on story. In each cell is an impatient little prisoner waiting to get out. You remember I told you the liverworts always lived where there was plenty of water. The water is the fairy that finally lets the prisoners free. It trickles into the pockets and fills them, and the prison walls swell and crack and free the captives. Funny-looking little things they are, too, when they get out! Put them in a little water on a piece of glass and look at them through your microscope, and you will see hundreds of little blunt-handled whips, each with a couple of lashes (Fig. 43, *c*), which have the singular power of whipping around without any help.

By some unknown means beyond our guessing these diligent little whips, sooner or later in their

active trips through the water, find the open mouths of the bottles in the seed disk, and whip themselves in. This was what the bottle was waiting for; and the ball in the bottle, and the whip which has found its way into it, enter on a very close partnership. Just such a partnership as this must be made for the formation of every seed.

In ordinary plants the seed formed in this way falls into the ground and makes a new plant, but the liverworts do not. Without leaving its home between the glassy fringes the seed grows till it makes the round pea which we saw in Fig. 42, *b*; this is made up of a quantity of a kind of seed called spores, and whole bundles of long elastic threads, which, when they are ripe, snap and flirt the seed everywhere about, so that one single seed produces thousands of spores, which sow themselves broadcast.

Besides these curious arrangements for sowing themselves, there is yet another. The liverworts,

when they find themselves in very comfortable quarters, get lazy; they grow and spread and take their ease, and don't seem to care whether any other liverworts come after them when they die or not; no little disks grow on them to make seed and sow themselves; but whether these disks

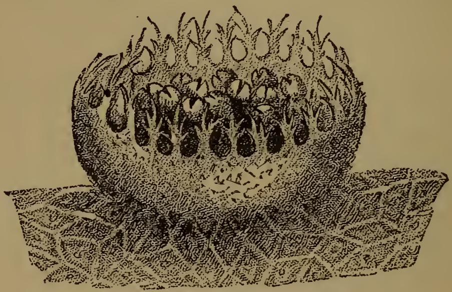


Fig. 44.—Cupule, or Nest
(*Marchantia.*)

grow or not, they almost always have on their leaves the little nests marked *c* on Fig. 39.

Now let us put one of these under the microscope and look at it. If it was hard to give any idea of the seed disk by means of a mere picture, it is impossible here. The nests are the most

exquisite things imaginable: the shape you see in Fig. 44, but they look as if they were carved out of a pale emerald, the fringed points shining and glistening, and down in the bottom of the nest lies a treasure-trove of carved gems of a deeper green. Over it all one would imagine diamond dust had been sprinkled, as it glitters and sparkles in the light. These little gems are spores which are washed out of the nest, and taking root, make new plants to bear new nests as beautiful as themselves.

Upon pots in most greenhouses you will find quantities of another kind of liverwort, not nearly so beautiful as the one I have been describing. Instead of the nests there are little crescent-shaped pockets which hold the spores. Another kind has a little upright flask which holds them. But whatever shape they may be, and whether the seed-making disks are on the leaves or not, some kind of cup or pocket for the spores is always formed.

Chapter X.

MOSSES.

You must have noticed, whether you live in the city or the country, how quickly a velvety coat of moss forms wherever it can get a chance. It needs plenty of shade and moisture, and where it finds these things it grows quickly: roofs and pavements, water-butts and troughs, tree-trunks and rocks, soon cover themselves with a rich plush garment of green or brown when left undisturbed, if they are in damp and shady places.

Moss was the world's first compass. Before people had ventured out into the great waters the compass was only needed to guide men through the forests on dark and cloudy days. By looking at the trees the wild hunter could tell where the north was, because the mosses

grow on that side, nestling in the shade, where the dew and the rain lie longest.

Perhaps you have never really examined moss. Looking at it carelessly, you have naturally thought that there were only a few kinds, and these kinds very much alike. Now if you are anywhere that you can study them, take your pocket-microscope, and you will find that you are very much mistaken. There are in reality a great many kinds of mosses, differing from each other almost as much as the flowers in your garden do. The moss-plant is so tiny that you must look through your microscope to see how really beautiful it is; but a careful examination without the help of the glass will probably show you much that you have never noticed before.

Before we go any further, let me tell you, if you have not one of the child's microscopes with all the little tools to dissect flowers and see insects with, how to make yourself some dissecting needles. Make with a penknife several little

bits of wood, something like a piece of a wooden pen-handle; into one end of each push the head of a No. 8 sewing needle. You can easily do this, if the little handles are made of pine or cedar, either by holding the needle with a pair of common pliers, or by pushing carefully against some wood, so as not to break the point.

When you are ready to dissect your leaf or flower, lay it on a small piece of glass. If the flower is light, put a piece of black stuff under the glass; if it is dark, put some white paper under it, to help you see it easily. Then take one of your needles in one hand and one in the other, and pull the object, little by little, to pieces. This is called "teasing out" the leaf. In this way you will find out a great many things about it which you would never find by merely pulling it to pieces with your fingers. If you have a microscope or magnifying-glass, put each piece under it and examine it closely. It is very interesting work, and when you find

one curious thing after another, you will never think of calling it tiresome. I have spent two steady hours teasing out a tiny water-plant to find one particular kind of bud, but I found it at last, and then all the work seemed easy enough.

While I was writing this I thought I would see if I could not find some moss in the garden, and in about five minutes I have gathered five different kinds of moss. One little patch that is lying before me I will tell you about, so that you may look for some like it; it is a very common kind. On a square inch of earth I found hundreds of little green clumps (Fig. 45). From among these spring up some slender red stems, from half an inch

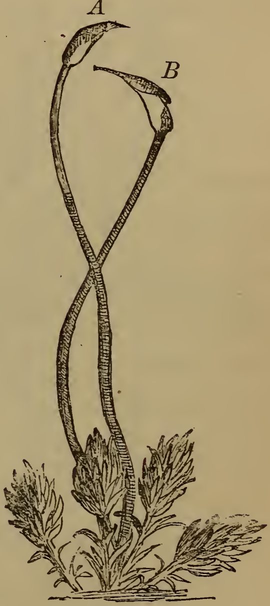


FIG. 45.
MOSS SPORE-CASES.
(*Funaria.*)

to an inch in height. Each of these stems bears a curved pod, some with caps and some without. In Fig. 45 the right-hand one, *B*, has its cap on, while *A* has lost its cover. The caps fit on so easily that I can lift them off with a touch. These pods are the little vases that hold the moss spores, from which new moss-plants will grow. When they are ripe, and ready to be sowed, the vase will attend to the business, and scatter them far and wide. The caps come off, and the tiny seed in the vase are blown out by the wind or washed

FIG. 46.—YOUNG MOSS PLANT.
A, spore; *r*, root; *l*, leaf;
B, young plant.

out by the rain. Other mosses have different shaped vases, some of them very beautiful.

A new moss-plant begins from one of the spores which lies on the ground. The dampness makes the spore begin to swell. One little bud pushes itself out at one end, and another at the other (Fig. 46, *A*). *A* is the spore, *l* the leaf-bud, *r* the root-bud. At first these buds seem just alike, but very soon we begin to see a difference: one bud lies on the ground, and gets brown and ugly, *r*; the other, *l*, grows up into the air and becomes green, and sends out little fairy-like stems and leaves. But both grow and spread, the leaf-bud to make the velvet sheet of moss, the root-bud to make a tangle which pushes its way into the ground below. Both the root-bud and leaf-bud are necessary to the life of the plant and to each other. The root drinks in the water and food from the earth; the leaf breathes in the air and sunshine. The happy little bud in the air is not too proud and selfish to help its ugly

Fig. 47.—Whip-case. *d*, whips escaping; *B*, whips coiled; *C*, whips free. (*Funaria.*)

little brother who is digging down into the earth. They work lovingly together, helping each other and all the family of which they are members. In Fig. 46, *B*, you see the beginning of a plant; the buds grow and branch, and set up cross partitions, so that what was at first one long narrow room or cell is now many such rooms placed end to end.

After the plant has grown, sometimes till it has covered several square inches of ground, it begins to get ready to grow the parts that correspond to a flower. Little buds curled up close in a bunch of leaves begin to grow on the ends of the branches. In the middle of each of these bunches grows a curious little

sack or bottle. In Fig. 47, *A*, is one taken out of the middle of a little bunch of leaves. This is a sort of whip-case with quantities of little double-lashed whips, *d*, escaping. *B* is one of the whips coiled in its little pocket, and *C* is another, free.

FIG. 48.—OVULE-CASE.
o, ovule.
(*Funaria.*)

While this whip-case has been growing, on the same plant, or another near by, another bud is forming in a bunch of leaves (Fig. 48). This bud looks like a bottle with a small body and a long curved neck. In the midst of the body is a round object: this is the ovule, the whips are the pollen, and when a partnership is formed between the two, we have the beginning of a true seed. This is all so much like the liverworts that I have not gone into it very particularly. If

you have forgotten look back at the last chapter. The whips, when they get out of the pockets, go lashing around in the water near the moss till they find the mouth of the bottle. They go in there, and work their way down to the ovule. Here the two seem to melt into one, and the seed is begun. If there is no water, and the partnership is not formed, the moss-plant drops its spores, and new plants are formed from them; but it seems better to have some seed plants every now and then: the moss-bed seems strengthened by them.

Fig. 49.—Sphagnum Enlarged.

The moss-plant, begun in either way, grows and

spreads, creeping over earth or bark or rock, till it makes a beautiful velvet bed; it sends up its pods and scatters its spores; new plants spring up, and so it goes on, and has gone on for thousands and thousands of years.

There is a very common kind of moss that grows in poor, miserable ground, which has some wonderful things about it. Fig. 49 gives a picture of the plant, magnified; in Fig. 50 you may see the beautiful whip-case of this moss.

I have tried to make the curious way in which leaves are built up of cells clear to you by comparing them to

FIG. 50.—WHIP-CASE.
d, whips and whip magnified.
(*Sphagnum.*)

houses with rooms built story above story and side by side. This moss I am telling you about is like a very large, rambling, one-storied house. It is not a private house, though, for there are ever so many rooms with round doors that open out, and in these rooms certain funny little water-insects take refuge just as coolly as if they had paid their rent and carried the door-key in their side pockets. Fig. 51 gives a piece of one of these leaves very much enlarged: *r*, *r*, *r*, are the rooms to let, and *l*, *l*, *l*, the doors into them.

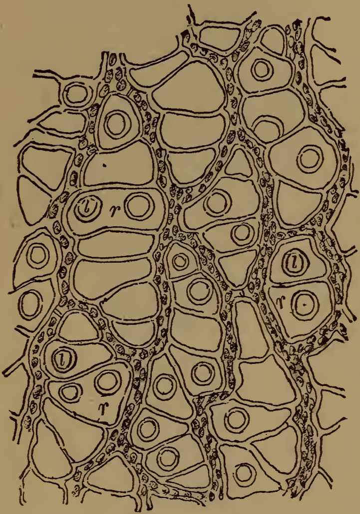


FIG. 51.—SPHAGNUM-LEAF MAGNIFIED.
r, *r*, *r*, rooms ; *l*, *l*, *l*, doors.

Mosses do not seem to be of much value; we are apt to think of them as poor, useless little

things of very little account, especially the dry sphagnum moss. But this is not really the case. Just as the wood of the trees that died thousands of years ago has made our coal, so the sphagnum moss of those old times has made the peat bogs of Ireland. You must have heard or read how the poor Irish people, who cannot afford to burn coal or wood, make their rooms warm and cook their meals by peat which they dig from the bogs. This peat is the sphagnum moss, packed layer upon layer, as year after year a new crop grew on top of the old one.

Chapter XI.

FERNS.

Out in the pleasant woods, where the shade is so thick that the sun cannot manage to get through the leaves to dry up the moisture, the ferns love to grow; they delight in mossy dells, and dripping rocks, and gently rippling streams, and about such places you will be most likely to find them large and fine.

Did you ever notice the little fern leaf as it lifts its head above the grass? It comes up, all curled up, hugging itself close to keep warm, it would seem. Pretty soon the coil begins to loosen, and the stem to straighten itself out, and the little leaves to unfold and stretch themselves in the sweet air and sunshine (Fig. 52).

Every child and very nearly every grown per-

son who roams the woods for wild flowers learns to love ferns: their fresh, bright, green, and delicate leaves make up for the want of blossoms. Some of them droop and fade very quickly in water, but others stay fresh for a long time, and make a beautiful bouquet of themselves, or with bright autumn leaves. Nothing else that grows is so beautiful and natural when pressed as fern leaves; perhaps that is why every one is tempted to gather them.

Fig. 52.—Young Fern.

Ferns, like the liverworts and mosses, do not bear flowers. Let us take any common fern and examine it. On the back of the leaf, if it is late enough in the season, you will find some patches which look like rust. On some leaves these splotches are spotted regularly over the leaf, or along lines (Fig. 53); on others they form a lace-like pattern; on others again they are dotted around the edge, as in the maiden-hair fern. When you look closely at this rust it appears like a sort of powder, but the minute you put it under a magnifying-glass you see how curious it is. Every grain of the dust is a little roundish case full of brown specks. The cases are sacs to hold the spores (Fig. 54, A, B). These spores, you re-

FIG. 53.—LEAF WITH SPORE-CASES ON BACK.

member, are a kind of seed, each one capable of producing a new plant. Nearly surrounding the sac is what looks like a necklace of clear beads: these beads are really a row of thick small cells that draw together as the whole case dries, and finally split open the case and let the spores free (Fig. 54, *B*).

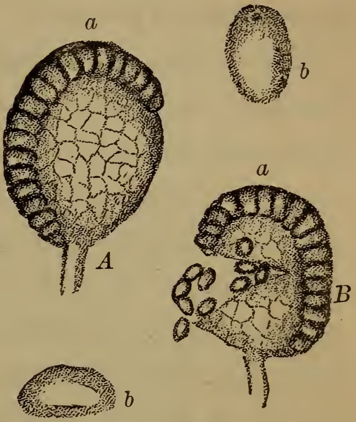


FIG. 54.

A, spore-case; *B*, case split open, letting spores escape; *b*, *b*, spores.

Different ferns have various kinds of spore cases; almost all of them grow in some sort of a pocket. Some fern leaves have shallow pockets on each side of the middle vein, or stem, that runs through the leaf; others have their edges doubled over to form the pockets. The maiden-hair fern has, as you know, beautiful polished black stems and shield-shaped leaves. In each scallop at the top of the leaf is

a pocket full of spore-cases, which looks, to your naked eye, like an ornamental dot to improve the appearance of the leaf.

If you happen to have some of the creeping Hartford fern, which is used so much for decoration, examine it, and you will see that it has all along the stem large leaves with no spots on the back, but at the end of each branch is a number of small and slender leaves; turn these over, and you will find the whole leaf covered with the rusty powder. Such ferns as these are sometimes called incorrectly flowering ferns. Correctly speaking, they have two kinds of leaves—one which bears and one which does not bear spores. The flowering plants belong to a higher class of vegetable life.

The fern family are not very aristocratic members of society in the vegetable world; they are classed with mosses and liverworts and other flowerless plants. But in their own class they stand highest; they are the first, as we go from

the lower to the higher, that have real roots, roots with a root-cap, and the curious air-vessels running through them, which you see in Fig. 55. Some of these air-vessels are wonderfully beautiful. Did you never notice, when you broke a tough, green, juicy stem of a plant, how some threads seemed to break hardest, and hung out of the broken end of the stem as if they had been stretched longer than the rest of it. These strings are the air-vessels: I would like to show you how beautiful they are when we look at them through a microscope. These fibres help to strengthen the plant, as your muscles do your body, and they are at the same time air-passages; they are both muscles and lungs in one. Every leaf and stem and root in all the plants that have flowers or fruit, in all the forest-trees—in fact, in every plant higher (not in size, but in kind) than the mosses—are full of these wonderful and beautiful air-vessels.

Since I cannot show you the vessels themselves,

I will do the best I can, and show the likeness of a bundle of them taken out of a fern leaf some time ago and put under the microscope (Fig. 55). Is not it wonderful that so much beauty should

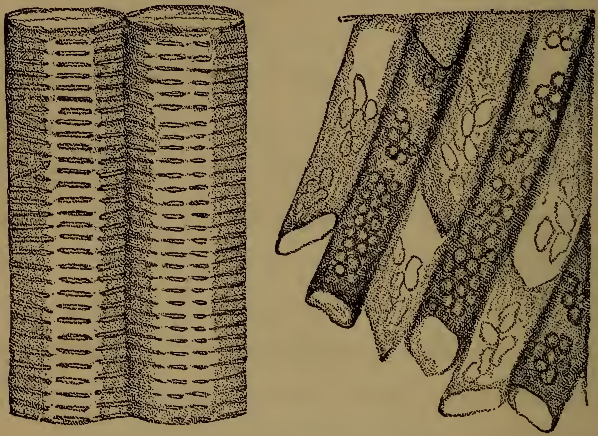


Fig. 55.—Air-vessels of Fern.

be hidden away in every leaf and stem and blade of grass where no one ever suspected it, until of late years men have found it?

Now let us take one of the tiny fern spores and drop it on the damp earth and see what happens.

The spore swells with soaking up the water, one side cracks open, and after a while a little bit of a white head, something like the end of a white worm, pushes itself out. As this grows it sets up partition walls, making new cells on every side, till finally we have a little thin, flat, pale green leaf lying close against the ground (Fig. 56). It holds to the ground, and sucks its moist-

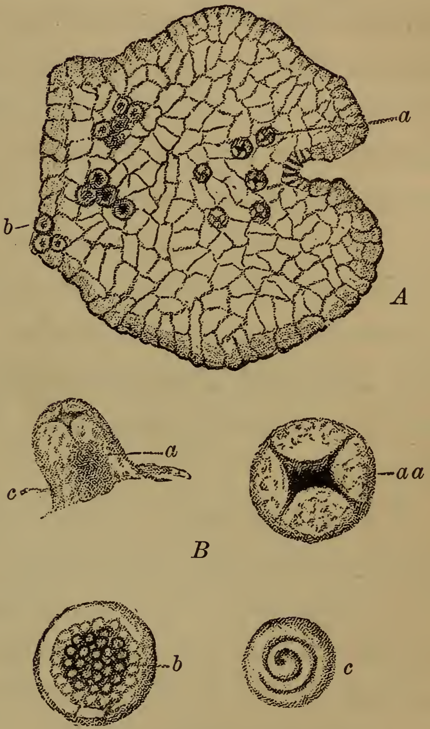


FIG. 56.—LEAF OF FERN.

A, Flat first-leaf; *a a*, ovule-cases; *b b*, whip-cases; *c*, whips coiled up; *B*, whip-cases and ovule-cases enlarged.

ure by thread-like root hairs growing from the lower side. On the upper side, after a while, little knobs begin to show, dotting the leaf irregularly. Under the magnifying-glass these dots are seen to be of two kinds. One kind has within it a round body (Fig. 56, *A*, *a*), the ovule; the other a number of little whip-cases, such as the mosses and liverworts have (Fig. 56, *A*, *b*). This leaf with these tiny knobs is what the fern has in place of flowers. The ovule is like those inside the moss and liverwort bottles; the whip-cases are also like the whip-cases in the mosses and liverworts.

When the ovule is ripe, and the whips completely grown, the knob opens; the opening above the ovule (Fig. 56, *B*, *a*) is filled with mucilage, which catches any of the unwary little whips lashing about in (Fig. 56, *B*, *c*) the water where the leaf is growing. A partnership is formed between the whip and an ovule, and together they grow into a true seed. This seed then acts like

any other seed, sprouts, sends out leaves and roots, and we have a fern plant. In ordinary plants the roots and stems and leaves grow first, and then comes the flower which bears the seed. In the mosses and ferns the part that stands in the place of a flower grows all by itself and produces its seed; this then grows into a plant, bears spores, which are rather like tiny slips or buds from the plant than like seed. These in their turn produce the little "first leaf," and so it goes on, two distinct and separate growths being necessary to fill out the whole life of every single plant of the fern family.

Chapter XII.

FLOWERS IN FANCY DRESS.

I REMEMBER as well as though it were yesterday how, years and years ago, when I was a very little girl, I very often roamed through the beautiful woods of Southern Ohio, hunting for a certain wild-flower.

The object of my search was a flower not often found, which we children called the Indian moccasin. It did look like a moccasin, indeed, with its round blunt toe and yellow, leathery, shoe-shaped pouch. I wonder if any prospector ever looked for signs of gold with more intense excitement than I felt when searching for my little golden shoe? Everywhere I turned, in my breathless haste, yellow moccasins seemed dancing before my eyes, and I hardly knew, till my eager hands

had grasped the stem, whether it was a real flower I had found or not. I hardly think I could have valued it more if I had known what I have since learned about the wonderful ways of the orchids, to which family my moccasin belonged.

You may never have found this particular plant in your rambles, and yet may know some other of the orchid tribe which grows wild in our woods. The common names are so different in different places that it is hard to tell you how to know them when you see them. The putty-root, and the lady's-slipper something like that in Fig. 57, are some of them. The flower

FIG. 57.—LADY'S-SLIPPER.
(*Cypripedium.*)

given in Fig. 57 is a cultivated plant, not exactly like any wild one, but a good deal like them.

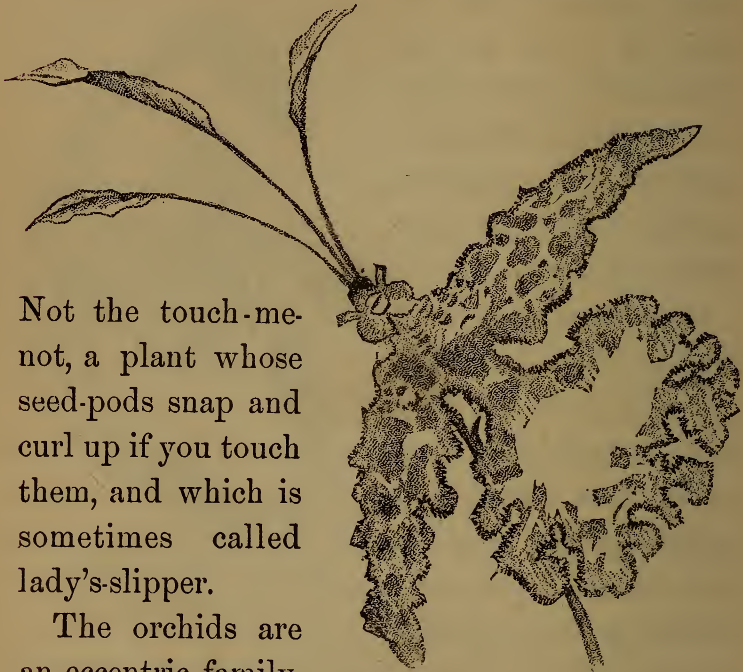


FIG. 58.—BUTTERFLY ORCHID. (*Oncidium.*)

Not the touch-me-not, a plant whose seed-pods snap and curl up if you touch them, and which is sometimes called lady's-slipper.

The orchids are an eccentric family. There is scarcely one of them which is not "queer" in some way or other. They seem

always to be trying to look or to act like something besides flowers. They imitate all sorts of things besides little Indian shoes. I wish I could take you into an orchid greenhouse and let you look around. You would think you had been invited to a fancy-dress party of the flowers.

There is one that looks for all the world like a swan, with its long curved neck; there is a beautiful butterfly with spotted golden wings (Fig. 58). Fig. 59 looks like a stalk up which some queer little ant-like creatures seem climbing. Bees and spi-

FIG. 59.—CLIMBING ORCHID. (*Calæna.*)

ders, done in brown and yellow, or perhaps more gorgeous colors, are all around. Here is a long spike of waxen flowers, and in the cup of each nestles a pure white dove with outspreading wings. The Spaniards have given it a name which means the flower of the Holy Ghost, from its resemblance to a dove.

These strange likenesses to other things are, however, the least wonderful thing about orchids. They differ from ordinary plants in many singular ways. Many of them, instead of growing in the ground, and drawing from it their food and drink, grow in the air, and take nourishment from it by means of their naked dangling roots. It seems sometimes as if living as they do, high up on the bark of trees, had put the notion into their heads of trying to look like birds and butterflies and bees.

The air manages to supply them with food, but they have to depend upon getting drink in some other way. Plants are a good deal like people

in that respect; they can manage to get along somehow with very little food, but they soon die of thirst if deprived of water.

In a wild state the air-plants grow on the bark of trees or on other substances, but they send their little roots into the moist bark or moss to get water. They do not feed on the juices of the trees, as parasites like the fungi and lichens and mistletoe do; they only want a standing-place, something to push against as they grow, and plenty of water. In the greenhouse they are usually planted in pots filled with bits of stone and damp moss, or they grow attached to the parent plant, as you may see in

FIG. 60.—YOUNG PLANT GROWING ON FLOWER STEM. (*Dendrobium.*)

Fig. 60, and send their roots out into the air for food. A few of them—the Indian moccasin, for instance—grow like common plants in the ground.

It would almost seem as if the orchids had an eye to business in their imitation of insects. At any rate, there seems to be a very good understanding between them, and constant business relations are kept up. The flowers always have a little pouch somewhere about them in which they keep a stock of honey on hand. Their beautiful colors and delicious smell attract, by day and night, bees, butterflies, and moths. In return for the "treat" which the flowers give, the insects render a valuable service to the plants.

I must remind you of something we have looked into before, and that is that every perfect seed is the result of a partnership entered into by the pollen grains or "whips" and the ovules of a plant. The pollen is the yellow dust which it is so easy to see on lilies and some other flowers; it is to flowering plants what the whips are in mosses

and ferns. The ovules are little round bodies lying in the swollen part of a flower where it joins the stem. Above the ovules, and connected with them, is the pistil, sometimes standing up in the midst of the stamens which make the centre of most flowers, sometimes it is only a sticky little pad, as it is in the orchids. Some plants get along perfectly well if this partnership is entirely a family affair, and the pollen of a flower falls on its own pistil, and makes a union with its own ovules; but this is not always the case. Certain plants require that the pollen shall be from another plant if the seed is to be sound and healthy. Orchids require this *cross-fertilization*, as it is called, and without the help of insects it could not be effected.

Bees and other flying visitors, it is found, always go in a single excursion from one flower of a kind to another of the same kind. They do not mix their drinks. This instinct not only serves to keep the honey stored by the bees pure,

but it enables the insects to carry the pollen just where it will be useful. The pollen of a morning-glory would die if put on the rose pistil. It must be placed on a flower of the same family as the one it came from, or one very nearly related to it, or it will do no good.

Now look at Fig. 60 and you will see that the flowers have a hollow tube in the centre, with a projecting lower lip. This tube is a single leaf or petal curled over to make a tunnel, and through this tunnel is the only path to the honey pouch. When a butterfly feels like taking a drink, and one of these orchids is near, he lights on the lower lip (*L*) of the tube, and pushing his long proboscis, or trunk, through it into the pouch, sucks up the honey. Now look at Fig. 61, *A*. This is a picture of the tube with its near wall cut away, so that you can see the inside arrangement. As he works his proboscis down into the honey pouch, *N*, it is pressed against *r*, and touches a spring there; the little cap at *r* snaps open, and leaves a sticky ball

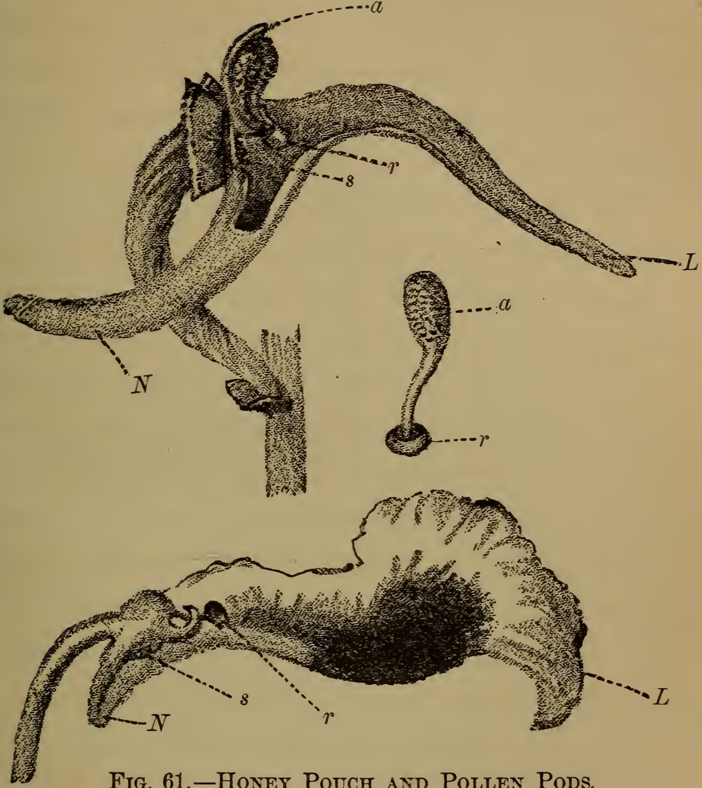


FIG. 61.—HONEY POUCH AND POLLEN PODS.
A, Orchis mascula; *B*, Dendrobium cut in two.

resting on the proboscis. As the butterfly goes on sucking, this ball dries as if it were glued to his trunk. When he draws his head out, this proboscis is ornamented with one or two little tufts which look like the trees in a child's toy village, as you will see in the illustration (Fig. 61, *C*).

Now look at the fragment of a flower in the part marked *A* of the same illustration. Suppose the pollen tuft to stay just where it is when the butterfly comes out of the flower. You can see by looking at the figure that it would strike *r* in the next flower it entered, and that would do no good: *s* is the place it should strike; *s* is the pistil. Now take an orchid flower, if you can get one; if not, look at Fig. 62, *A*, and see what will happen. I push into it a sharpened lead-pencil, and it comes out with the pollen tuft standing up as it does on the butterfly's trunk. Watch it a minute. As it dries, the stem of the tuft bends down towards the point of the pencil. Now push it into another flower. Wait a little while—a

minute perhaps—and take the pencil out. You will see that the pollen has been pulled out of its little case. If you tear open the flower, you will find the pollen sticking so tight on the pistil, *s*, that you can scarcely brush it off. In this upper flower the drawing is from Mr. Darwin's book, but the lower one is one of the flowers in Fig. 60

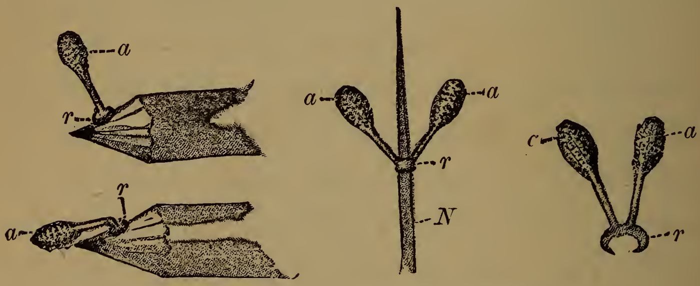


Fig. 62.—Pencil and Needle, with Pollen.

which I picked off the plant after drawing it, and tried with a pencil myself. *r* in the lower drawing looks like a little purple velvet pouch swung lightly on its stalk. The pencil came out, leaving the little bag empty, and the pollen glued fast to

its side. But they were not glued so fast that they were not pulled off by the next flower that the pencil entered.

Some of the orchids have two pistils, one on each side. In these, if you push into the tube a bristle or needle, the two pollen cases come out as in Fig. 62, *B;* as they dry, they spread apart, and

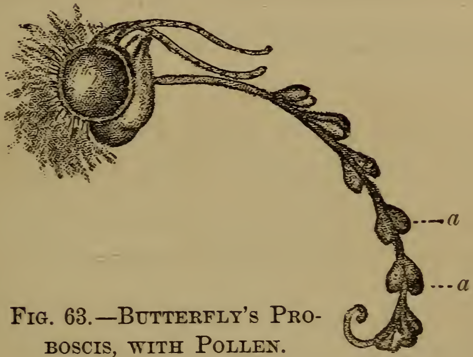


FIG. 63.—BUTTERFLY'S PROBOSCIS, WITH POLLEN.
a a, double pollen-pods, glued on.

bend forward so that both pistils are struck at once as it is pushed into the next blossom. The contrivances by which each orchid receives on just the right spot exactly the right pollen are

perfectly marvellous. I have only told you a very few of the simplest facts in regard to the help the insects give to the flowers. Many a poor butterfly goes through life having its proboscis loaded down with the glued-on pollen cases (Fig. 63, *a a*). It is one of those business arrangements which does not work equally well for both parties. All this is beautiful for the flowers, but it seems rather hard on the butterflies.

CHAPTER XIII.

"*PICCIOLA.*"

THERE is a beautiful little French story which has been translated into English and called "Picciola," the Italian for little flower. It is the story of a French nobleman who was thrown into prison on an unjust charge of plotting against the government of his country. He was a man of talent and education, as well as of wealth and position. Somehow, with all his life had given him, it had never taught him to look with open eyes at nature, or to see beyond nature a God who had created it.

He was restless and impatient in his close cell and the little strip of court-yard where he paced up and down, and up and down, in his misery, longing to be free. One day he saw between

the heavy paving-stones of the yard the earth raised up into a tiny mound. His heart bounded at the thought that some of his friends were digging up from below to reach him and give him his liberty again.

But when he came to examine the spot closely he found it was only a little plant pushing the earth before it in its effort to reach the light and the air. With the bitter sense of disappointment which this discovery brought, he was about to crush the little intruder with his foot, and then a feeling of compassion stopped him, and its life was spared.

The plant grew and throve in its prison, and the Count de Charney became every day fonder of his fellow-prisoner; he spent hours, which had before been empty, watching it as it grew and developed, until it became the absorbing interest of his life. As he watched it day by day, and saw the contrivances by which it managed to live and grow, he was compelled to believe that there

must be, somewhere, a great and wonderful power that could design and make so marvellous a thing. The little flower was like a little child taking him by the hand, and leading him away from his dark, bitter, unbelieving thoughts into the light of God's love.

I want to take some common flower, something you have seen a hundred times every summer of your lives, and show you a few of the marvellous contrivances that make it able to live and grow and bear blossoms and fruit. If you will study them closely for a while, it will not seem so strange then that the Count de Charney, who had lived so many years without learning anything of the wonders of nature, should have had them opened for him by one little flower that he had carefully watched and studied.

Most plants higher than the ferns are alike in having roots, stems, and leaves, and some sort of flower and seed-vessel. But the parts look so very different in different plants that it is some-

times a little hard to tell which is which. In some the roots grow in the air, and in others the stems grow underground. It is only by studying what the parts do that it is possible to be sure what they are. The most important part of every living thing is its stomach, because everything that lives must eat and drink, or die. There are some very curious plants which have regular stomachs into which their food goes, just as it does in an animal, and is digested, but these are not very common. After a while we will come to these strange plants, which I have called vegetable pitchers and queer traps. Ordinary plants have roots to supply them with food and water in the place of a stomach.

Let us study the roots of some plant. Any ordinary plant will do. If you can do so, get a hyacinth glass and bulb. The bulb is the root, and looks very much like an onion; the glass is a vase made for the purpose of growing hyacinths in water. It slopes in from the bottom upward,

and then bulges out suddenly. The bulb rests in this bulging part, and has water below it and around its lower part. The glass being clear, you can see the roots grow as plainly as you can see a leaf or a flower-bud unfold. Perhaps you have no hyacinth glass, and cannot get one; then try to make one for yourself out of a small glass jar. There will certainly be a pickle bottle or a preserve jar about the house which will answer perfectly well. All you want is to have the bulb rest half in and half out of the water, with room below for the roots to spread through the water. Be careful to keep the water up to the right mark by adding a little every day as the plant soaks it up.

Or you may take a dozen grains of seed corn, soak them overnight, and then plant them an inch deep in a box, having about six inches or more depth of good earth. In about three days the blade will come above ground. Put your hand or a trowel down beside one of the plants,

and scoop it gently up. Be sure you make your hand or trowel go away down below where the seed was planted, so as not to bruise the tender growth. Shake and blow the dust away, and you will see several little white thread-like roots coming from the grain. If you take up in this way all the young plants, one or two every day, you will see how they sprout and grow.

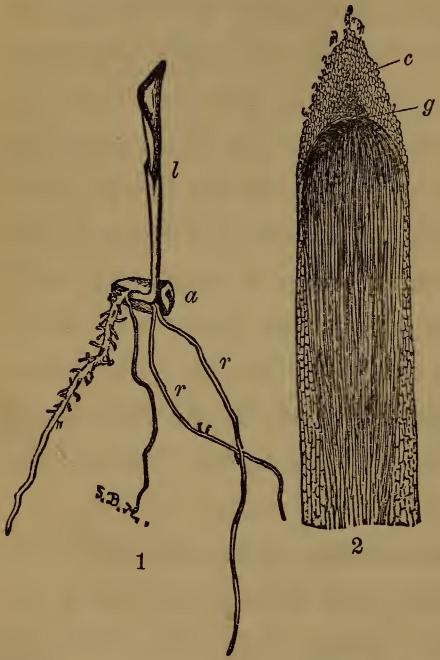


FIG. 64.—CORN AND MAGNIFIED ROOT.

(1) Corn four days planted; *r*, *r*, *r*, roots; *l*, leaf; *a*, grain of corn. (2) Root magnified; *c*, root cap; *g*, growing point.

(*Zea mais.*)

If you have a microscope and a sharp knife, carefully split the end

of one of these roots and look at it. If you have not, you will have to trust me so far as to take this drawing as correct (Fig. 64). All these tiny roots have a cap over their growing end, so that when they have to push their way among the hard earth and stones, the growing part will not get bruised. These roots take in all the water and the food which the earth supplies to the plant.

The hyacinth can grow in water alone, because it has been a provident little body, and has stored away enough food in the little round carpet-bag of a bulb to supply the plant for the few weeks of its life. It only asks for the water it needs to keep it alive and growing. When the thirsty little roots have sucked up water enough, the bulb begins to grow in the other direction. If you look, you will see a solid lump of pale green come up from the top like the horns of a calf, or a baby's tooth. This is the young plant coming up out of its dark cradle into the light and air and sunshine. The delicate growing end of the

plant, which will after a while bear its beautiful spike of bells, is very tenderly wrapped up in the leaves. After it gets through the tough skin of the bulb, the plant grows straight up. It stretches itself after its long sleep in the sweet air and light, the leaves lengthen and broaden and open out, and the stem with its little knobby buds comes up in the midst. These will soon grow and unfold into beauty and fragrance, now you will be rewarded for all your long waiting, if watching the wonderful growth day by day has not carried its own reward with it.

Many plants are grown from roots or bulbs, but a greater majority by far come from seed. Tulips and lilies, onions and potatoes, are all instances of plants grown from new roots which sprout out from the old ones. The root is in every case the beginning, the seed the ending, of the life of a plant.

Take two of the commonest of our window and garden plants—the geranium and the heart's-

ease. Let us take the geranium first. On the cluster of bloom we will probably find flowers partly withered, flowers full-blown, and buds

FIG. 65.—GERANIUM PISTIL.

(1) *p*, lily pistil; *b*, *b*, pollen grains; *c*, where cut was made across. (2) *c*, the cut piece showing ovules; *o*, ovule. (*Pelargonium.*)

nearly ready to open. Look at a full-blown flower. You will see with your naked eye something standing up in the middle which looks like

a tiny pink lily; around it are little rounded white spikes. If you carefully strip off the green cap outside, and then the colored petals, you will find a lily like the one in the figure (Fig. 65); this is called the pistil. Now open one of the nearly blown buds; you will find the lily pistil still closed, and on two of the spikes around it two double-barrelled rosy pods. When the pods, or stamens, are nearly ripe, they look for all the world like a pink gum-drop made in the shape of a French roll. If they are ripe they look as you see in Fig. 66.

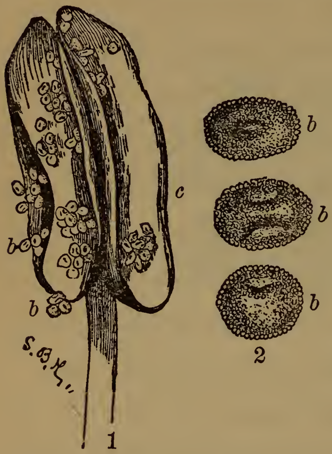


FIG. 66.—GERANIUM STAMEN AND POLLEN GRAINS.

(1) *a*, stamen with pods burst open; *b*, *b*, pollen grains. (2) *b*, *b*, *b*, pollen grain much enlarged.

(*Pelargonium.*)

To make a perfect seed the pollen and ovule have to enter into partnership. The stamen

sends out thousands of clear orange pollen grains (Fig. 66, *b*), and when these fall on the top of the lily or pistil, as some have done in Fig. 65, they stick fast. The lily, for all its innocent look, has laid a trap for them; it is covered with a sticky substance which holds them fast. The tiny pollen grain begins to send out a tube like a little hose-pipe, which grows down and down to the bottom of the lily. There it finds some very small egg-shaped bodies called ovules (Fig. 65, *o*). The busy little hose-pipe pushes its way into a little opening at the end of one of the ovules, pumps away till the pollen grain is empty, and the liquid out of it is all safely stored in the ovule, and then it withers away. The ovule when it is ripe is a seed, but if the pollen has not emptied itself in the way just described, the ovule dies.

One of the most curious plants we have, in some respects, is our common corn—Indian corn. When it is "in tassel," at the top of the stalk is a

great bunch of dull-colored flowers. If you look carefully at them you will find that each is a leafy case, and out of this, like the clapper of a bell, hang several pods. When the pods are ripe, out of an opening at the lower end pours a cloud of pollen, which fills the air around the corn-stalk. We have seen how carefully the pollen is guided to the pistil in orchids, the methods used to make sure the meeting and combining of the two cells, the pollen, or whip, and the ovule, being very wonderful and various. In some plants, like the corn for instance, it is left a good deal to chance—the wind blows the pollen about—but to prevent failure millions of pollen grains are grown and dispersed, with the chance of one here and there reaching the pistil. In the corn the pistil is in a very queer place. I am sure you must have seen the cook pulling off the green leaves or husks from an ear of green corn, or perhaps you have done it yourself. Out of the little end of the husks hangs a bunch of fine

silky threads. Each one of these threads is a pistil; it is a hollow tube, and terminates at its farther end in a little sac holding an ovule—it is like the bottles in the liverworts and mosses, only it has a tiny little body and a long, long neck.

It seems hardly possible, and yet it is true, that every single grain of corn that ever grew was made by a partnership between a pollen grain from the top of the corn-stalk, and this little, buried, wrapped-up ovule, down deep under the green leaves of the corn-husk. How do you think the pollen ever gets at the ovule? It has not the power of whipping around and making its way down these tubes. A little pollen grain blowing about in the air, is blown against a thread of corn-silk; this, like other pistils, is sticky, and it stays there. Pretty soon the pollen grain pushes out a little nose, as the seed and spores do when they begin to sprout; this little tube pushes its way down and down, right through the whole long length of the corn-silk.

It never sets up a single partition wall in all this long distance. After a while the pollen tube finds the ovule down a long passage-way, and then the partnership is formed.

Every strand of silk on a perfect ear of corn, when the grain begins to form, is a double tube — one tube the silk, with another, the pollen tube, running its whole length inside it. When the contents of the pollen grain is pumped through this long hose-pipe into the ovule, then, and not till then, the seed corn begins to grow.

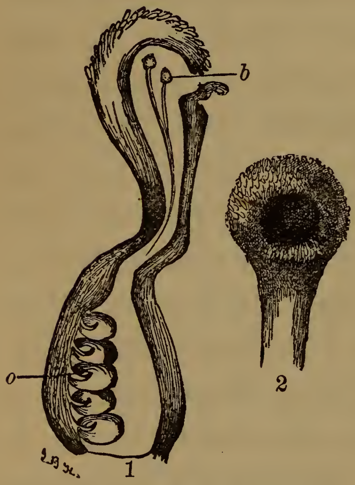


FIG. 67.—PISTIL OF HEART'S-EASE.

(1) Side view of pistil sliced in two. *b*, pollen grains which have found their way in; *o*, ovules. (2) Front view of pistil not cut.

(*Viola tricolor.*)

The very next time you can do so, examine an ear of corn carefully.

You will find each thread of silk leads to a single grain. If any place is found on the cob where a grain is wanting, it is because, for some reason or other, no pollen tube ever gained its way to the ovule, and so the ovule withered and died.

If you look at Fig. 67, you will see the pistil of a pansy, or heart's-ease. No. 1 is a side view of the pistil sliced down so you can see into it, as you can into a baby-house. You see the pollen grains, *b*, sending down their tubes to the ovules, *o*. No. 2 in this drawing is the front view of the heart's-ease pistil. The beautiful colored leaves of a flower are only meant to cover and protect the pistil and the pollen of the plant, as the fruit is meant to cover its seed. There has been a tender care for us in all this that the covering for both should have been made so beautiful and so delicious.

Chapter XIV.

CLIMBING PLANTS.

Have you never wondered, when you looked at a tangle of grape-vine or morning-glory stems, how they came to twist themselves together so? Perhaps you had some sort of a notion that they got tangled up as a bunch of silk or a skein of worsted lying loose might do. Examine any vine which you can find growing near you, and see how different the tangle is from a snarl of thread: there is a regular twist, the branches coiling in the same direction. In some plants the turn is from right to left, in others from left to right.

There must, of course, be some reason for this, and we can best find it out by taking a young plant, a seedling, and watching what it does from the start.

It would be very natural to think that plants moved only as stones do, because something pulled or pushed them; but this would not be a true conclusion. Every plant that we know much about is firmly fastened by its root in the ground; the movements of its leaves and flowers seem only caused by the blowing of the wind or the beating of the rain. But though plants are anchored fast to the earth, they are all the while moving as they grow.

Take some seed — beans will do — and after soaking them, plant them in the ground about two inches deep. In a week or ten days you will see the earth cracked all about. This is not merely because the growing plant acts like a wedge and splits the earth open, but because in growing the first little leaves move round and round, boring their way out of the ground very much as a corkscrew works its way into a cork, and cracks the earth around it. The first leaves of most plants—a bean, for instance—do not come

straight up out of the seed; but when the seed coat bursts from the swelling of the inner part a

FIG. 68.—THE BEAN. FIRST LEAVES IN DIFFERENT STAGES.

little arch projects, which raises itself up. This arch is the stem, and after a while the leaves are pulled out of the sheath, and the arch widens out,

and finally straightens up. You have often seen a man who had a heavy weight to lift bow himself over and receive the weight, and then lift it by straightening himself, as the stem does to lift the leaves (Fig. 68, first leaves). The root burrows into the earth in very much the same way as the stem revolves, by going around and around as it grows (Fig. 69). Take a morning-glory vine, and let it lie without any wire or trellis to catch hold of. After a while you will find the stems and tendrils coiled round each other in a tight twist (Fig. 70); you could not begin to twist them so tightly yourself without breaking the stem.

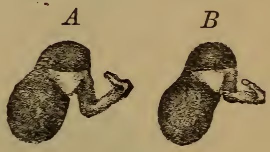


FIG. 69.—MOVEMENT OF ROOT OF BLACK BEAN.
A, position at nine o'clock; *B*, position half an hour later.

The tips of all growing plants, like the first leaves that pierce the ground, move around; they are forever weaving their magic circles in the air; they take many hours sometimes to make a single

turn, but they are as regular as the hands of a clock, and never forget and go backward. I have been watching some wistaria branches lately, and

Fig. 70.—Morning-glories.
(*Convolvulus.*)

have been very much interested to see the new shoots, as they grew rapidly in the soft warm air, taking a slow turn around the wire placed

to support them, very much as you might wrap your arm about a swing-rope to take a better hold. If there is a post or a wire near, you do not have to give your vines the twist they need to climb; they do their own twisting as they grow, and always in this quiet, deliberate way.

You have no doubt noticed that a Virginia creeper does not need a wire to climb by; it grows beautifully up any wall which has little unevennesses. Now look, if you can get hold of a new shoot, what the creeper has to help it along. It sends out tendrils that branch into many ends, and each one of these ends swells and becomes a sort of sticky pad, which glues itself to the wall (Fig. 71).

FIG. 71.—VIRGINIA CREEPER. (*Ampelopsis.*)

These little pads, when they find no wall to fasten themselves upon, remain small, and finally wither

away. Those on the spray in Fig. 71, which was trailing from a vine, are so, some small and some quite gone; but look at the pads in Fig. 72, which were detached from a painted board, and see how they look through the microscope. Very much like a boy's India-rubber sucker, are not they? Some of these have the paint from the board still sticking fast on them; others are all sparkling with the dried mucilage, which makes them look as if they had been sprinkled with sugar.

Fig. 72.—Pads through the Microscope. (*Ampelopsis.*)

These little many-armed suckers give the plant a firm hold, while its head waves around until it touches some surface again, and again the pads lay hold for another upward stretch.

There must be some curious arrangement by which plants, that cannot *feel* and *will* as animals do, can move. They have no brains to think with, no nerves to feel with: it is strange to believe

that they really do move with a reason. Mr. Darwin has examined the subject so closely that he has taken nearly six hundred good-sized pages to tell all he has found out about it. His ways of finding out are many. One method is this: he takes a small stiff bristle and glues it on the growing part of a shoot. By watching this shoot and comparing it with other shoots which had no bristle attached, he could not detect any difference in the movements. Above the little branch with the bristle attached he placed a piece of glass that had been smoked, so that the bristle, as it moved with the movement of the tip, would travel over the glass. He did not need to stand by and watch the branch; he could go away and attend to anything he chose, and when he came back there on the glass was a history of the travels the shoot had made, written by itself. He managed to hang up a sprouting bean or pea, so that the root recorded its own movements in the same way. There were other ways which he used, all

of them being ingenious, and requiring the greatest attention to get a correct map of their movements. He found that every plant in growing moved around as well as upward, but that some moved far more than others: the ones that grew tall and slender and needed support would send out shoots that swayed round in bigger and bigger circles until they could reach something to sustain themselves by, or else they would fall in helpless heaps on the ground.

Mr. Darwin was not a man to be satisfied with finding that a thing is so. He never rested until he found just how it came about. I do not mean to say that he was the only man who studied these things, for there were many others who did; but he wrote about what he had studied in such a clear and simple and interesting way that anybody could understand him, and so people who don't pretend to be very wise in such matters read Mr. Darwin's account and nobody's else; and are apt to forget, though he is always careful

to mention their names and what they have done, that any one else deserves any of the credit.

By closely studying the little cells of which the leaf or stem is made up, he found that when, for any reason, a plant needed to turn in a certain direction, the water in the stem rushed from the inner to the outer part of the curve, making the cells on the inner side of the stem a little smaller, and those on the outer a little larger, than usual. After a while the stretching of the outer cells makes them grow and stay larger (see in the figure how it must be, Fig. 73), and so the curve remains. You cannot straighten a stem curved in this way without breaking it.

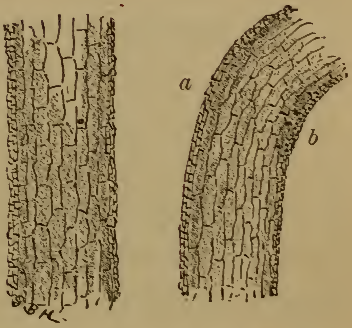


FIG. 73.—DIAGRAM OF STRAIGHT AND CURVED STEMS.
a, stretched cells; *b*, crowded cells.

Every movement of stems and leaves comes

from the movement of the water that fills their cells. But besides the water, there is something else just as important, and that is the sun. The water is only a servant, which obeys the light as its master. Many flowers turn their bright faces always to the light. They follow the sun as he moves through the heavens all the day long from his rising to his setting. This comes from the effect the sun has on the water in the stem, and not because the flower is beginning to "take notice," as the baby's bright eyes do of a lamp when it is moved about a room, though it does remind one of it.

The movement of climbing plants is only one of many curious movements that are made by stems and roots and leaves and flowers, though the cause is the same in all cases.

Chapter XV.

VEGETABLE PITCHERS.

Nearly seventy years ago a gentleman living in North Carolina began to watch some very curious plants which he found growing in a poor piece of land near his home. Hundreds of people had probably seen these plants, but Dr. McBride seems to have been the first who really studied them and wrote down what he found out about their ways.

Out of the moist ground a tuft of leaves grew; some of these were ordinary leaves, others were extraordinary. To examine the last you might almost think that the fairies had been up very early in the morning with their thimbles and needles and invisible silk, and had selected a leaf here and there in the tuft, and doubled it around,

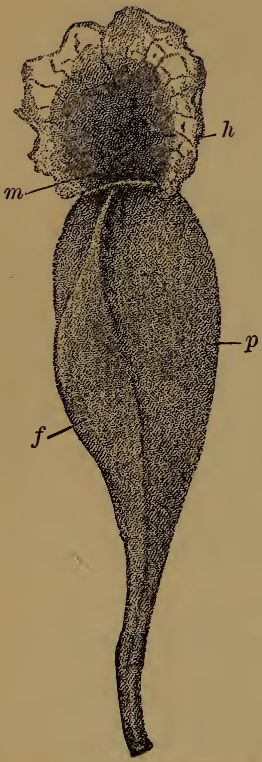


FIG. 74.—OPEN-MOUTHED PITCHER.
f, seam, with honey trail; *p*, pitcher part; *h*, hood; *m*, mouth.
(*Sarracenia purpurea.*)

and sewed the edges together, so as to make a long slender pitcher to catch the summer rain in. If the fairies were responsible for these pitchers, they must be very good seamstresses indeed, for such a seam you never saw. You may look at it through the largest kind of a magnifying-glass, and not a stitch can be seen, not a knot nor a loose thread.

The raw edge of the seam is always turned outward. Look at Fig. 74. Here is a single pitcher which grew not far from New York City, in a swampy place. Any fine day in May you will be pretty sure to find some of

these pitchers for sale at the small stalls on Fourteenth Street, between Fifth and Sixth avenues, if you happen to be in New York, and are on the lookout for them (*f* is the seam and *p* the pitcher). Above the pitcher you see a curved and veined leaf, *h*, which stands up and partly curves over the open mouth, *m*. It does not quite cover it, so some rain usually gets into the hollow tube.

FIG. 75. — PITCHER WITH OVERHANGING HOOD AND CLEAR WINDOWS.

h, hood; *w*, windows; *f*, honey trail; *c*, cord around mouth; *m*, mouth.

(*Sarracenia variolaris.*)

These curious trumpet-shaped leaves are not grown for the benefit of the fairies, nor even for the beetles and flies which often pack the lower part of the tube

full, but are for the use of the plant on which they grow. I have never found insect remains in the pitcher you have first been looking at, but in Fig. 75 I have taken out hundreds, sometimes packing the tube up for four inches or more. These trumpets are the stomachs of the plant; the flies and insects in the trumpets are the remains of many dinners—those parts of the insects which they could not digest.

Plants usually, as we have found out, feed by means of their roots. The food they get is in the ground, and the roots push down into this, and suck up out of it what they need to keep them alive and make them grow. The pitcher-plants live in very poor soil, where they can find very little to nourish them. They get little besides water through their roots. They would die, just as you or I would, if they had nothing but water to live on, so they are provided with these stomach-pitchers.

Before you eat your food some one has to get

it and cook it; then you have to chew it and swallow it. If these plants had one-half of all this to do to get fed, there would be none of them on the earth now; they would all have died out long ago. But these pitchers, besides being stomachs to digest the food, are traps to catch it. Along the edge of the raw seam (*f*, Figs. 74 and 75) are rows of honey glands, so that from the ground to the edge of the pitcher's brim there is a trail with honey drops leading a careless insect on and on, and up over the edge, *c*, into the hollow of the trap. Once inside, there is no hope for him, for the inner part is covered with delicate hairs pointing downward towards the pit below. An ant, a fly, and many another insect can walk straight up a pane of glass, or on the smoothest ceiling, and yet it will go reeling and tumbling along on this hairy floor. The sticky pad it has on its feet, its claws, and even the patent little sucker which aids some of them in holding on, all go for nothing when it undertakes to

stroll on this bending, moving, uncertain wall inside the pitcher's brim. In a second the unwary visitor slips and falls, no matter how hard he tries to save himself. Even with the advantage of wings an insect seldom escapes, but soon forms part of the liquid mass filling the lower part of the pitcher—a horrible mixture, part water, part a juice which oozes out of the trumpet-leaf, and part dead and decaying insects.

There is something very horrible in the idea of a plant, a beautiful plant, too, luring insects to its trap, and then feeding on them like a dreadful old ogre. In one or two of the pitcher-plants at the upper end are clear spots which let in the light. Against these skylights the trapped flies strike and bump, as they do against a window-pane, till they fall into the pit below (*w*, Fig. 75). This pitcher-plant, as well as that shown in Fig. 76, is rich with beautiful colors, red and yellow and olive green, with clear pale yellow transparent windows, and above the cluster of these leaves

grow the stems which bear their flowers.

One of the most beautiful of these plants grows in the Sierra Nevada Mountains, in Northern California, so high that the flower may be found blooming higher up than the top of Mount Washington or any mountain east of the Mississippi River. It is too high up in the world to have any every-day name, but is called, in part after its native State, *Darlingtonia californica*. This has no common leaves at all, but from the root spring two kinds of pitchers — little

FIG. 76.—PITCHER-PLANT IN BLOOM.
(*Sarracenia rubra.*)

baby pitchers, something like those in Fig. 76, and others, large, beautifully colored and veined pitchers, with a curved-over roof and two long flaring wings (Fig. 77, *Darlingtonia californica*).

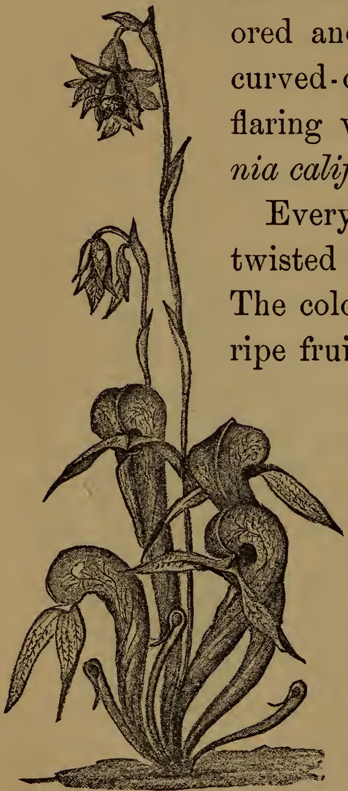


FIG. 77.—DARLINGTONIA CALIFORNICA.

Every one of these pitchers is twisted round about half a turn. The colors are like those of rich ripe fruit—brilliant reds and yellows and greens; not brighter than those of the other pitcher-plants, but richer and mellower. The flower of this, too, is very curious. It grows on a tall stem four or five feet high, and looks like a rich red and yellow striped tulip hanging down,

but with an extra row of petals above. The flower is arranged as a trap too. It, like the orchid traps, draws the insects flying about to itself, and by feeding them with honey induces them to carry the pollen of the flower to the sticky place where the pollen dust must rest to make the flower bear seed. Then—it is hard to think of this beautiful plant without feeling that it is a traitor—it lures the insects to its pitchers and devours them.

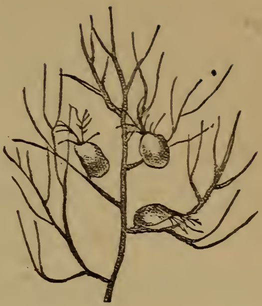


FIG. 78.—BLADDER-WORT. (*Utricularia.*)

FIG. 79.—BLADDER WITH CAPTURED PREY.

There are many other plants which devour insects as the vegetable pitchers do. Among them are some very curious little things

that grow sometimes in water, sometimes in the air, and occasionally in the earth. The English people call them bladder-worts, because on the stems or roots or leaves little tiny cups grow, which were formerly supposed to be useful as bladders to float the plants. Closer study of them has shown these to be traps too. One of the most curious of these traps may be seen in Fig. 78.

The plant you see here is one which has no leaves, only branching stems. This is one of the kind that live in water. It goes floating around, looking like the most innocent of plants, until some unwary animal comes near the mouth of one of the bladders (Fig. 79). In a minute the mouth or trap-door opens, the victim is gulped down, and slowly dissolved and absorbed. Inside the stomach you will see a quantity of little irregular stars with four rays. These are the organs that take up the nourishment which the unfortunate prey supplies.

Chapter XVI.

SOME QUEER TRAPS.

I want to take you with me some bright summer day on a little visit to the boggy lands of southern New Jersey. Close beside a cranberry patch let us stop and look at this great bed of wild flowers. The ground is covered as thick as they can stand with spikes of delicate rosy flowers and long narrow green leaves, sparkling in the sunshine as though they were set with millions of bright jewels. These cannot be rain-drops, for it has not rained for a week, nor dew-drops, for the sun is high, and the dew would have been dried up long ago. Look close, and you will see that each narrow leaf is covered with tiny stalks, each tipped with a bright drop of what looks like dew. Touch it, and you will find the drop to be

sticky. The sun, which dries common dew or rain drops, draws out this sticky substance. From this fact the plant is commonly called sun-dew (Fig. 80).

Fig. 80.—Sun-dew Plant.
(*Drosera.*)

The sun-dew in the picture is not the one we have just found growing, but belongs to the same family. The principal difference between them is that it has round green leaves instead of long narrow ones; but what is true of one is equally true of the other, so far as its general behavior is concerned.

It had long been known that the sticky drops on the sun-dew

leaves served as a trap to catch insects, but it was not fully known why the insects were so caught and how they were disposed of until Mr. Darwin began to watch them and study their ways. If anybody in the world could get the truth out of a plant or animal, Mr. Darwin was the man. He tried a thousand ingenious ways of cross-questioning them by tests and experiments. There are few more interesting stories than that told us about the ways of the flesh-eating plants. The sun-dew is one of these; the insects it captures are for food.

Look at this leaf, which was picked from a sun-dew plant and looked at through a magnifying-glass (Fig. 81). It is somewhat the shape of a palm-leaf fan, fringed around the edge, and covered over the upper surface with strange prolongations. These are called tentacles, because they are something like the arms of some sorts of sea animals, with which they capture their prey. The leaf is not perfectly flat, but, as you can see by looking

at Fig. 80, it sags a little in the middle, making it slightly cup-shaped.

FIG. 81.—SUN-DEW LEAF MAGNIFIED, SHOWING TENTACLES.
(*Drosera leaf.*)

For some reason insects seem to be very fond of flying around the sun-dew plants, and sooner

or later they are pretty sure to brush their gauzy wings against a leaf or light upon one. Then there is no hope for them; they stick fast, just as unfortunate flies stick to the fly-paper spread open to catch them.

Watch that happy little fly sipping honey from one flower after another. Now see him settle down right on the middle of one of the sparkling, harmless-looking leaves. He is caught. No struggles will loosen the poor little feet glued fast by the sticky drop on the tentacle. His struggles to free himself are only making his capture more certain. The touch of his feet, light as it is, is like the touch of a telegraph operator's finger upon his instrument. The fly sends not one message by his touch, but hundreds—one to every tentacle on the leaf, telling it to come to the central office and get its share of the booty captured. In response every tentacle begins to curve over to the middle of the leaf, until at last the miserable fly is caught in a hundred arms.

The message goes slowly, and the movement of the tentacles is slower still—so slow that it takes from one to five hours for the movement to cease after the insect is caught. When the fly alights on the side of the leaf, or anywhere away from the middle, the tentacle it touches bends over, carrying its prey with it, to the centre of the leaf, and then the arms all begin to move towards the middle and clasp it. Sometimes, when the insect is not on a long tentacle, and so cannot be carried to the middle, only the arms on that side clasp it.

But the most curious part is not the catching of the fly. Many other kinds of sticky leaves and buds catch flies; the sun-dew devours them. The leaf acts precisely as your stomach does after you have been eating; it pours over the insect a liquid acid which dissolves what is good for food. This dissolved food causes the flow of another liquid, called the gastric juice. In your stomach the gastric juice has the power of turning the food

you have swallowed into blood, which makes flesh and bones; it, in fact, builds up your body day by day, and makes you live and grow. The gastric juice of the sun-dew builds up its body in the same way, only instead of blood and flesh it makes sap and cells.

If you want to keep well, you must eat the right sort of food, and so must the sun-dew. One poor little plant that Mr. Darwin was experimenting upon turned yellow and sick, and finally died of dyspepsia, after having been fed for a long time on nothing but cheese.

One full meal lasts a sun-dew leaf a good while, usually nearly a week. After a fly, or a bit of meat, or anything proper in the way of food, has been seized and digested, the tentacles slowly open out. That means that it is hungry again, and ready for another meal.

Of course when the plants grow wild they have to depend, like other savages, upon the prey they capture, and often they must go hungry. In try-

ing to find out all about these curious plants they have been fed with all sorts of things—meat and milk, and different kinds of soup. When a few drops of milk are poured on a leaf it will very often curve up around the edges, making the cup deeper, and the tentacles at the same time bend over to get their share. The leaf makes in this way sometimes a round and sometimes a three-cornered cup. One very strange thing has been found out: if a small piece of meat is cut in two, half of it placed on a sun-dew leaf, and the other on some damp moss close by, the meat on the moss spoils, and is filled with living things, like any spoiled meat, but the piece on the leaf stays fresh until it is digested.

Another plant which lives upon the prey it captures is the Venus's fly-trap (Fig. 82). It grows in great quantities on the poor lands of North Carolina. It has few and small roots like the sun-dew. The leaves grow out from the centre of the plant. From the same place the flower

stems and roots also grow, just as is the case in the sun-dew. Only three leaves are given in the picture. The plant usually has from eight to

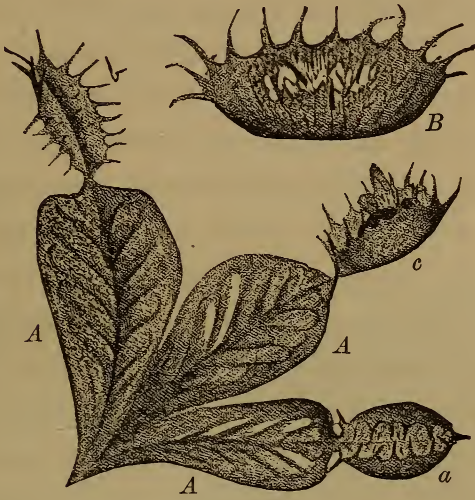


FIG. 82.—LEAVES OF VENUS'S FLY-TRAP.
A, *A*, *A*, three leaves of Dioneæ; *B*, half the trap, showing sensitive hairs; *a*, opening and empty; *b*, open; *c*, closing over fly.
(*Dioneæ.*)

twelve; the flowers are quite large, of a delicate greenish-white. The whole leaf is not a trap, but on the tip of each leaf you see them: *b* is open;

c is closing over a fly which it is about to make a meal of.

The traps, you see, are a little like the two valves of a clam-shell, hinged together at the back, and edged all around with sharp spikes. On the inner side of each shell are three long hairs; these hairs (*B*, Fig. 82) are very sensitive, and the instant they are touched the valves close, the spikes locking together as your fingers do when you clasp your hands. If the thing caught in the trap is not fit for food, the valves open before long; but if it is the right sort of food, the spikes stay closely clasped until the food is digested, and then they open and drop out any remains which were of no use to them, such as the horny coat of a beetle, and are ready for another feast.

One day when I was looking through a fine collection of plants in a greenhouse on Madison Square, New York, I caught sight of a very singular bunch of leaves (Fig. 83). I said to the gardener: "What is that? It is very curious."

"Yes," he said, taking the pot up in his hands; "they are queer little fellows, the thirstiest little rascals I ever saw; can't get enough water anyhow," and he dipped the whole pot into a cask of water, filling up the pitchers on the ends of the leaves to the brim. The picture (Fig. 83) is taken from a sketch made on the spot. It comes from Australia, and is still, I believe, very rare; this is the only one I ever saw. Its habits and manners do

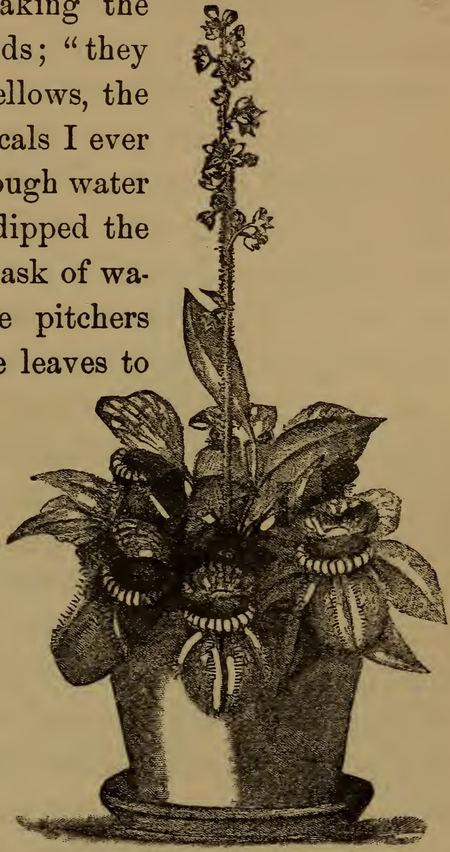


FIG. 83.—AUSTRALIAN PITCHER-PLANT. (*Cephalotus.*)

not seem to have been as carefully studied as some of the other flesh-eating plants, but it is a near cousin of the last and most curious of these traps.

These last of the "queer traps" grow chiefly in the islands of Polynesia. In shape they are something like the vegetable pitchers we saw in the last chapter, but their way of really digesting food shows that they are nearer kin to the sundew than to the pitcher-plants.

The plants are large, with many leaves, the stem, after running through the middle vein of the leaf instead of stopping at the tip, runs right through it, and grows one or more feet beyond the tip of the leaf. On the far end of this stem is a graceful pitcher, with two fringed flaps down the front, and a leaf hinged on for a lid which is sometimes open and sometimes shut (Fig. 84). The pitcher is usually partly filled with a sticky liquid. Some of these pitchers are half a yard high, and would hold quarts and quarts of water. The plant bears great spikes of beautiful flowers, and

the pitchers themselves are gorgeous in color—green and red and pink, with curious markings. The rim around the mouth is beautifully ornamented, and inside the mouth is a sort of funnel of projecting points, leading down to the trap below. You have probably seen the same sort of arrangement in a rat-trap; it is very common. Small birds attracted by the smell or color of the flower, or the hope of a drink from the reservoir below, make their way down. It is a trap easy to enter, but hard to escape from in the face of the points. In its

Fig. 84.—Bird Trap. (*Nepenthes.*)

struggle for freedom the poor little fluttering thing gets its wings wet and sticky, and is either drowned at once, or lingers on and is finally digested by its beautiful captor. This is turning the tables truly, when vegetables catch and devour birds, instead of being destroyed and eaten by them.

These are perhaps the most wonderful family of plants that we know anything of. They seem to be leading us away from the vegetable world and to be introducing us to animal manners and customs, and so seem to bring to a natural close our studies in plant life.

THE END.

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